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ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

12/01/91

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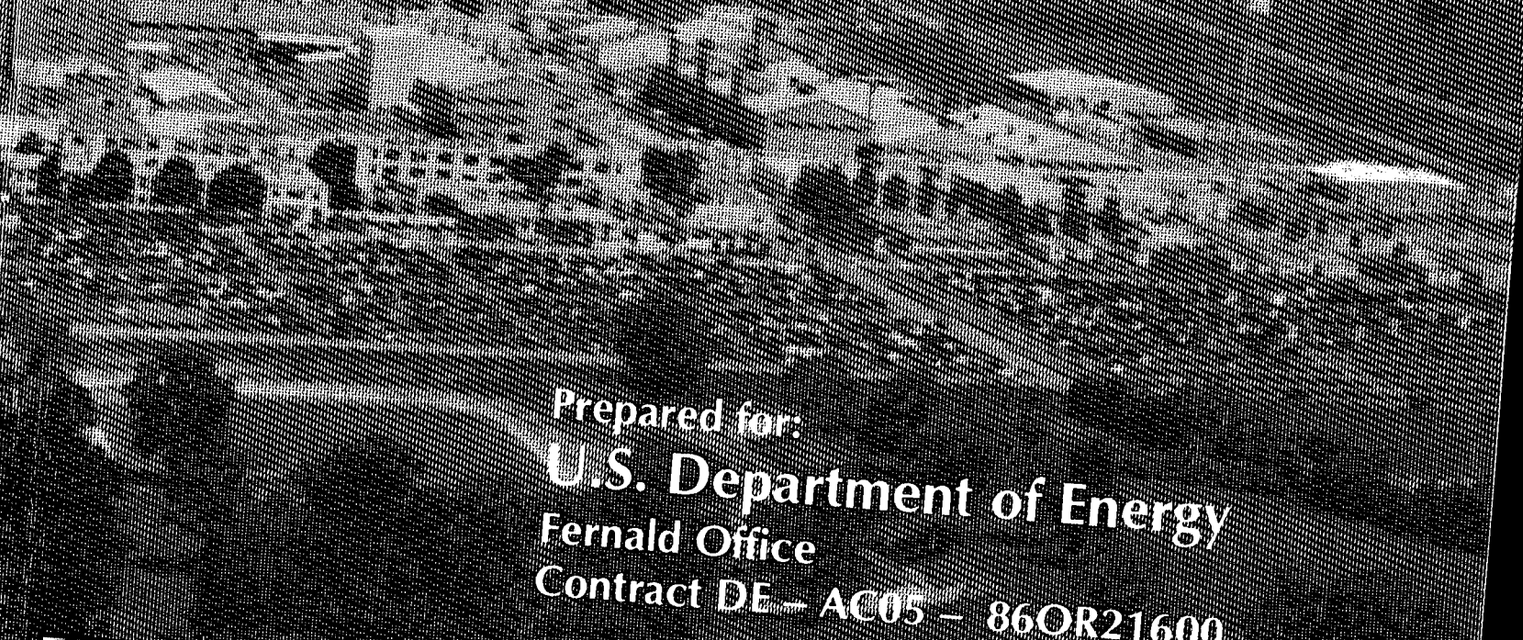
REPORT

1990

FMPC – 2245
Special UC – 707
December 1991

FEED MATERIALS PRODUCTION CENTER

Annual Environmental Report for Calendar Year 1990



Prepared for:
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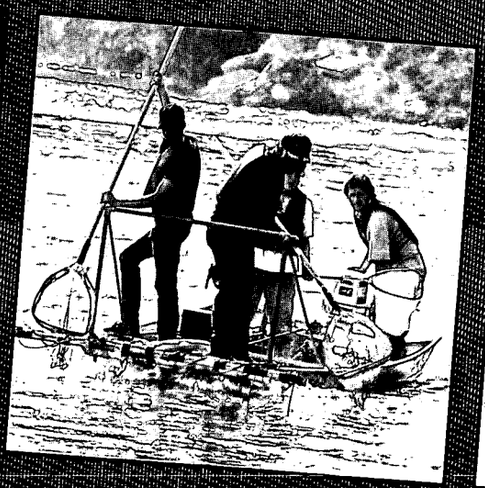
Fernald Office
Contract DE – AC05 – 86OR21600



by the
Environmental Management Department
Westinghouse Materials Company of Ohio

FEED MATERIALS PRODUCTION CENTER
Annual Environmental Report

FMPC – 2245
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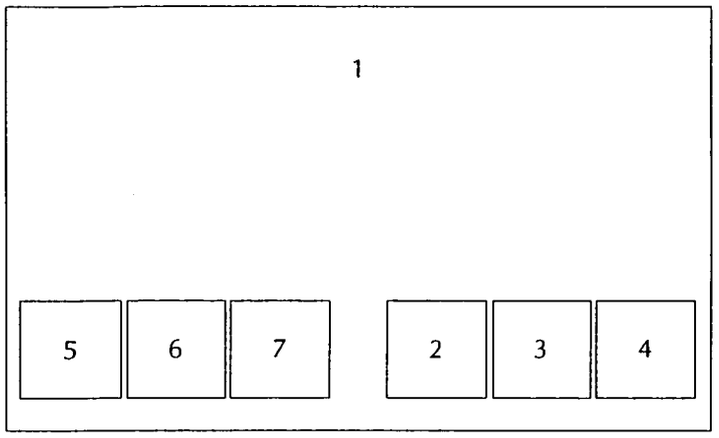

1 – The Feed Materials Production Center processed low-enriched uranium metal products from 1951 to 1989. Today, the site is in the midst of an extensive environmental restoration project.

2 – Robins at the FMPC are the subject of a Miami University biology study.

3 – A University of Cincinnati biology team collects annual fish samples from the Great Miami River to see if FMPC operations have adversely affected the fish populations.

4 – Groundwater is sampled both on- and offsite to track any pollutants that may have originated from the FMPC.

5 – The FMPC regularly collects samples of air, water, soil, produce, and various other media to monitor for both radioactive and nonradioactive pollutants.

6 – Ten underground storage tanks were removed during 1990.

7 – The FMPC is located about 27 km (17 miles) northwest of downtown Cincinnati, Ohio.

FEED MATERIALS PRODUCTION CENTER
Annual Environmental Report for Calendar Year 1990

Prepared for: **U.S. Department of Energy**
Fernald Office
Contract DE – AC05 – 86OR21600

Prepared by: **Environmental Management Department**
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FEMP – 2245
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December 1991

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Acronyms

AER	Annual Environmental Report
AHF	Anhydrous Hydrogen Fluoride
AMS	Air Monitoring Station
ANSI	American National Standards Institute
BAT	Best Available Technology
BDN	Biodenitrification Facility
BOD,5	Five-Day Biochemical Oxygen Demand
BOD,C	Carbonaceous Oxygen Demand
BMP	Best Management Practices
BSL	Biodenitrification Surge Lagoon
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DOE	Department of Energy
EA	Environmental Assessment
EDL	Economic Discard Limit
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
EM	Environmental Monitoring
EML	Environmental Measurements Laboratory
EMR	Environmental Monitoring Report
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
FS	Feasibility Study
HSL	Hazardous Substances List
ICRP	International Commission on Radiological Protection
MGD	Million Gallons per Day
NAAQS	National Ambient Air Quality Standards
NCRP	National Council on Radiation Protection and Measurements

NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
OEPA	Ohio Environmental Protection Agency
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
PCB	Polychlorinated Biphenyls
PEIC	Public Environmental Information Center
PET	Proficiency Environmental Testing
PACD	Proposed Amended Consent Decree
PTI	Permit to Install
PTO	Permit to Operate
QA	Quality Assurance
QF	Quality Factor
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation and Feasibility Study
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SSLS	Storm Sewer Lift Station
S&DM	Sample and Data Management
SU	Standard Units
SWOAPCA	Southwestern Ohio Air Pollution Control Agency
SWRB	Stormwater Retention Basin
TLD	Thermoluminescent Dosimeter
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency

Conversion Table

In this report, the metric system is used to measure length, volume and mass, while the English system units are often presented in parentheses for the reader's reference. To measure radioactivity, exposure, and dose, the traditional radiological units (Curie, Roentgen, rad, and rem) are used; for conversion to the Systeme International units (Becquerel and Sievert), use the conversion factors in this table.

Length

1 centimeter (cm)	=	0.3937 inches
1 meter (m)	=	1.09 yards
1 kilometer (km)	=	0.62 mile
1.61 km	=	1 mile

Volume

1 milliliter (mL)	=	1 cubic centimeter (cm^3)
	=	0.061 cubic inch
	=	0.0338 fluid ounce
1 mL of WATER	=	1 gram
1 liter of WATER	=	1 kilogram (kg)
1 liter (L)	=	1000 mL
	=	0.264 gallons
	=	1.057 quarts
1 cubic meter (m^3)	=	35.3 cubic feet (ft^3)
1 Drum Equivalent (DE)	=	55 gallons
	=	0.21 m^3
	=	7.4 ft^3

Mass

1 gram (g)	=	0.0353 ounce
	=	0.0022 pound
1 kilogram (kg)	=	2.2 pounds

Activity

1 picocurie (pCi)	=	1 x 10^{-12} Curies
	=	2.22 disintegrations per minute (dpm)
	=	0.037 Becquerel
1 microcurie (μCi)	=	1 x 10^{-6} Curies
	=	3.7 x 10^{4} disintegrations per second (dps)
	=	2.22 x 10^{6} dpm
1 Curie (Ci)	=	3.7 x 10^{10} dps
	=	2.22 x 10^{12} dpm
	=	rate of decay of 1 gram of radium-226
1 Becquerel (Bq)	=	1 dps
	=	27 pCi

Exposure

1 roentgen	=	2.58 x 10^{-4} coulombs per kg of air
	=	amount of gamma or X rays required to produce 1 electrostatic unit of electrical charge in 1 cm^3 of dry air under standard conditions

Dose

1 millirem (mrem)	=	0.001 rem
1 rem	=	0.01 sievert (Sv)

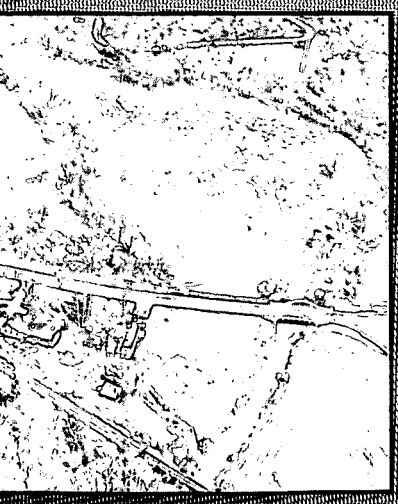
For Natural Uranium in Water

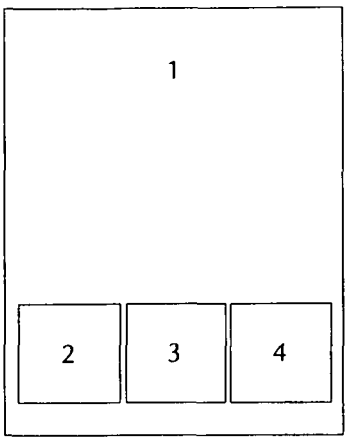
1 microgram (μg) U/L	=	1 part per billion (ppb)
	=	0.6757 pCi/L
1 milligram (mg) U/L	=	1 part per million (ppm)
	=	675.7 pCi/L
1 pCi U/L	=	1.48 ppb

For Natural Uranium in Soil

1 μg U/g	=	1 ppm
	=	0.6757 pCi/g
1 pCi U/g	=	1.48 ppm

Executive Summary





1 – The small industrial town of Fernald is less than two miles south of the FMPC; over 4,500 people live within five miles of the center of the site.

2 – Neighboring residents live literally "across the street" from the FMPC property.

3 – Local gravel pits and businesses operate between the FMPC and the Great Miami River, less than half a mile to the east.

4 – The City of Ross (population: 2,124) is less than two miles northeast of the FMPC site.

Executive Summary

During 1990, the FMPC accelerated its transition to an environmental restoration site from one of production. After 37 years of producing low-enriched uranium metals for the Department of Energy, environmental cleanup has become the top priority at the FMPC. Production was suspended in July 1989, and, in October 1990, the department transferred management responsibility from its "Defense Programs" organization to the DOE Office of Environmental Restoration and Waste Management.

In February 1991, DOE announced its intention to formally end production (rather than suspend it) and submitted a closure plan to Congress. This closure plan became effective in June 1991. To reflect the new cleanup mission at the Fernald site, DOE on August 23, 1991 officially changed the name of the facility to the Fernald Environmental Management Project (FEMP). Concurrently, Westinghouse Corporate changed the name of its Fernald subsidiary to Westinghouse Environmental Management Company of Ohio.

Since this report is a summary of environmental monitoring and restoration activities for 1990, it will refer to the site by its former name — the Feed Materials Production Center (FMPC). This is consistent with the role of the Annual Environmental Report (formerly the Environmental Monitoring Report) to act as an historical reference for a particular year. As such, the report reflects conditions at the site as they existed in 1990. Next year's report will refer to the site as the Fernald Environmental Management Project.

Environmental Monitoring and Restoration

As restoration efforts to manage the low-level radioactive and hazardous wastes stored onsite continue, Environmental Monitoring (EM) continues to check yearly progress in reducing potential contamination to the surrounding environment. Environmental Monitoring at the FMPC primarily examines air and water as possible routes through which pollutants, particularly radionuclides, may leave the site. Levels of direct radiation originating primarily from the K-65 Silos are also measured. Concentrations of radionuclides detected offsite are converted to potential doses to nearby residents through mathematical models. These offsite concentrations are compared to environmental standards, and doses are compared to DOE- and USEPA-regulated exposure limits.

The Scope of this Report

This Annual Environmental Report presents the 1990 Environmental Monitoring sampling data for the air and liquid pathways and gives the estimated doses calculated from these EM data. Also included in this report are the site-wide Environmental Compliance Self-Assessment, information on Quality Assurance practices, a summary of waste management activities, and the RI/FS progress through 1990.

Other environmental activities at the site include routine onsite monitoring of liquid wastes according to the National Pollutant Discharge Elimination System permit and problem-identification and solution-development through the Remedial Investigation and Feasibility Study.

Environmental Monitoring Results

Results of Environmental Monitoring sampling are found in Chapters Four, Five and Six — these chapters summarize the air and liquid pathway sampling for both radioactive and nonradioactive pollutants. Significant results are noted in the following paragraphs.

Air Pathway

Chapter Four focuses on the air pathway, including not only sampling at air monitoring stations, but also sampling of soil, grass, produce, and milk, all of which may become contaminated through particulate deposition.

Air sampled for uranium and trace radionuclides showed that all average concentrations measured along the fenceline and offsite were less than 1% of the DOE guideline. Airborne uranium emissions for 1990 were estimated to be 3.2 kg (7 pounds), the lowest in the history of the FMPC. Average radon gas concentrations along the FMPC fenceline were

consistent with 1989. All 1990 boiler plant emissions were well below permit limits.

Soil sampling showed that, although some locations northeast of the site had uranium concentrations above background levels, uranium concentrations were consistent with previous years and were well below action levels set by USEPA and DOE. Uranium concentrations in grass were generally lower than in 1989, and uranium concentrations in produce were consistent with previous years' data.

Uranium concentrations in milk were below analysis detection levels for most months during 1990, which was consistent with previous years' results. However, milk samples collected during the same months from both a local dairy and a distant Indiana dairy had uranium concentrations above the detection levels. Contamination after sample collection or laboratory problems are suspected.

Liquid Pathway

Chapters Five and Six present liquid pathway sampling results. Chapter Five covers all aspects of effluent and surface water monitoring, along with sediment and fish sampling. Chapter Six addresses groundwater sampling from both FMPC and privately owned wells.

About 786 kg (1,729 pounds) of uranium were discharged to the Great Miami River through FMPC effluent in 1990; this is a slight reduction from 1989. Thorium and strontium were also detected in the effluent, but at concentrations less than 3% of the DOE guideline. Downstream from the FMPC effluent line, concentrations of uranium in Great Miami River water were less than 0.1% of the DOE guidelines. The highest offsite uranium concentration in Paddy's Run was 9.7% of the guideline; the creek receives some stormwater runoff from the site.

Radionuclide concentrations in river and creek sediments were consistent with previous years' data and did not indicate a buildup of radioactive pollutants in the sediment. Uranium concentrations in fish from the Great Miami River were consistent with previous years and showed no impact from FMPC operations, as the fish appeared to be in good general health.

In sampling liquid effluent for general water-quality indicators, the site's discharge was shown to be in compliance with the new, more restrictive NPDES permit limits 99% of the time during 1990. In addition, concentrations of fluoride, nitrate-nitrogen, and chloride and pH values in the river and Paddy's Run showed little or no effect from FMPC operations.

Groundwater sampling for radionuclides from FMPC on- and offsite wells showed uranium, thorium, radium, strontium, and technetium at concentrations above the DOE guidelines in specific locations. Areas of particular concern are being evaluated, and one removal action has begun south of the site. Private well sampling for uranium showed results consistent with 1989, and the three non-drinking water wells that had concentrations above the DOE guideline were the same wells identified in previous years.

FMPC onsite groundwater sampling for nonradioactive hazardous wastes has detected concentrations of arsenic, cadmium, nitrates, and volatile organic compounds above drinking water maximum contaminant levels. Monitoring and evaluation continue. Private well sampling for nonradioactive pollutants showed only iron and manganese at concentrations above the drinking water standards, but these elements are found at naturally high concentrations in this region.

Estimated Radiation Doses for 1990

Offsite radionuclide concentrations determined through EM sampling are entered in mathematical models and potential radiation doses to nearby residents from various sources are calculated. These estimated doses are described by source in Chapter Seven, and the estimated dose to the maximally exposed individual from a combination of sources is presented.

In 1990, the maximally exposed individual living near the K-65 Silos, eating local produce, beef, and fish, and drinking Great Miami River water could have received a maximum committed effective dose of 10 mrem. This dose is only 10% of the 100 mrem limit for all pathways established by the International Commission on Radiological Protection and adopted by DOE. This 10 mrem dose can also be compared to 100 mrem per year received from natural sources (excluding radon). The estimated effective dose from radon for 1990 was 69 mrem and was consistent with the estimated radon dose for 1989. The natural background radiation dose from radon is 200 mrem.

CONCLUSIONS

Environmental Monitoring results for 1990 indicated that pollutant concentrations in air, liquid effluent, and surface water were consistent with or decreasing from previous years' results. All air pathway components, surface water, sediment, and fish were well within applicable limits. Effluent discharge was in compliance with NPDES permit limits 99% of the time.

Some groundwater samples, onsite and south of the site, have indicated areas of concern for aquifer contamination. These areas continue to be closely monitored, and receive additional attention in the RI/FS program. The South Groundwater Contamination Plume Removal Action is underway as an immediate response to limit access to and use of contaminated water and to control plume migration. Privately owned wells continue to be sampled for uranium, and 1990 results show that all wells used for drinking water were well within the DOE guideline of 22 pCi/L.

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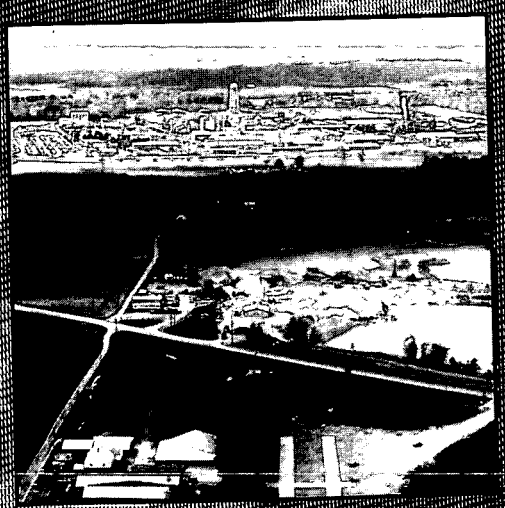
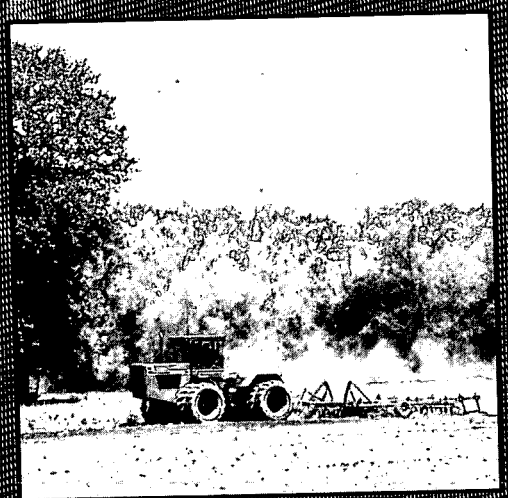
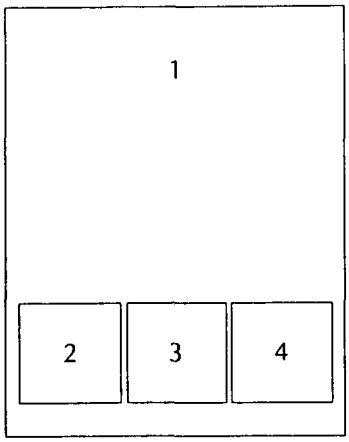
CHAPTER 1







1 – Paddy's Run cuts north-south through the FMPC property and provides a natural drainage channel; an FMPC runoff control project is underway to reduce pollution to the creek and groundwater systems.

2 – Local pit operations harvest sand and gravel from the same aquifer that the FMPC overlies.

3 – Farming and raising cattle account for the majority of the land use in the area surrounding the FMPC.

4 – Crosby Elementary School, two miles from the center of the FMPC, is the location of an FMPC emergency siren and an air monitoring station.

CHAPTER ONE

Introduction

In recent years, the Feed Materials Production Center (FMPC) has been expanding its Environmental Monitoring Program and conducting a thorough site-wide investigation of the environmental conditions at the site and surrounding areas. Work related to the environment has been given the highest priority. Indeed, the FMPC reached a turning point in its history on July 10, 1989. On that date, production operations were indefinitely suspended after more than 37 years of manufacturing uranium-metal products for United States' defense programs. In February 1991, the United States Department of Energy (DOE) submitted a plan to Congress that formally stated DOE's intention to permanently end production. The basis for these decisions was to allow employees to focus their efforts on environmental programs designed to determine the extent of contamination and to clean up the site.

To help readers understand the material presented in the rest of this report, this chapter contains the following introductory sections:

- **The FMPC Mission: Changing from Production to Restoration**, including the purpose of the Environmental Monitoring Program,
- **Local Geography**, an introduction to the physical, ecological, and economic characteristics of the area,
- **Exposure Pathways to Humans**, which looks at the physical and biological surroundings as possible routes for FMPC contaminants to reach the local communities, and
- **Environmental Standards and Guidelines**, describing the various standards with which the FMPC must comply, with regard to protecting the local environment.

The FMPC Mission: Changing from Production to Restoration

Today's mission at the FMPC is to achieve environmental compliance and restoration, whereas in previous years, the FMPC's primary mission was to produce uranium metal. Planning for the FMPC began shortly after the end of World War II when the United States recognized the need for new facilities to produce uranium metal. Existing facilities, developed for the war effort, were not economical to operate nor able to meet increasing demands. The Atomic Energy Commission wanted to increase the quality and quantity of uranium metal as well as improve control and increase the safety of production operations.

After evaluating several sites, the government selected a 425 hectare (1,050 acre) area just north of Fernald, Ohio as the site for a new production facility (Figure 1). The FMPC is located about 27 km (17 miles) northwest of downtown Cincinnati, Ohio. Ground was broken on May 16, 1951, and the first uranium derby was produced at the FMPC's Pilot Plant on October 11, 1951. The major portion of construction was completed by 1954.

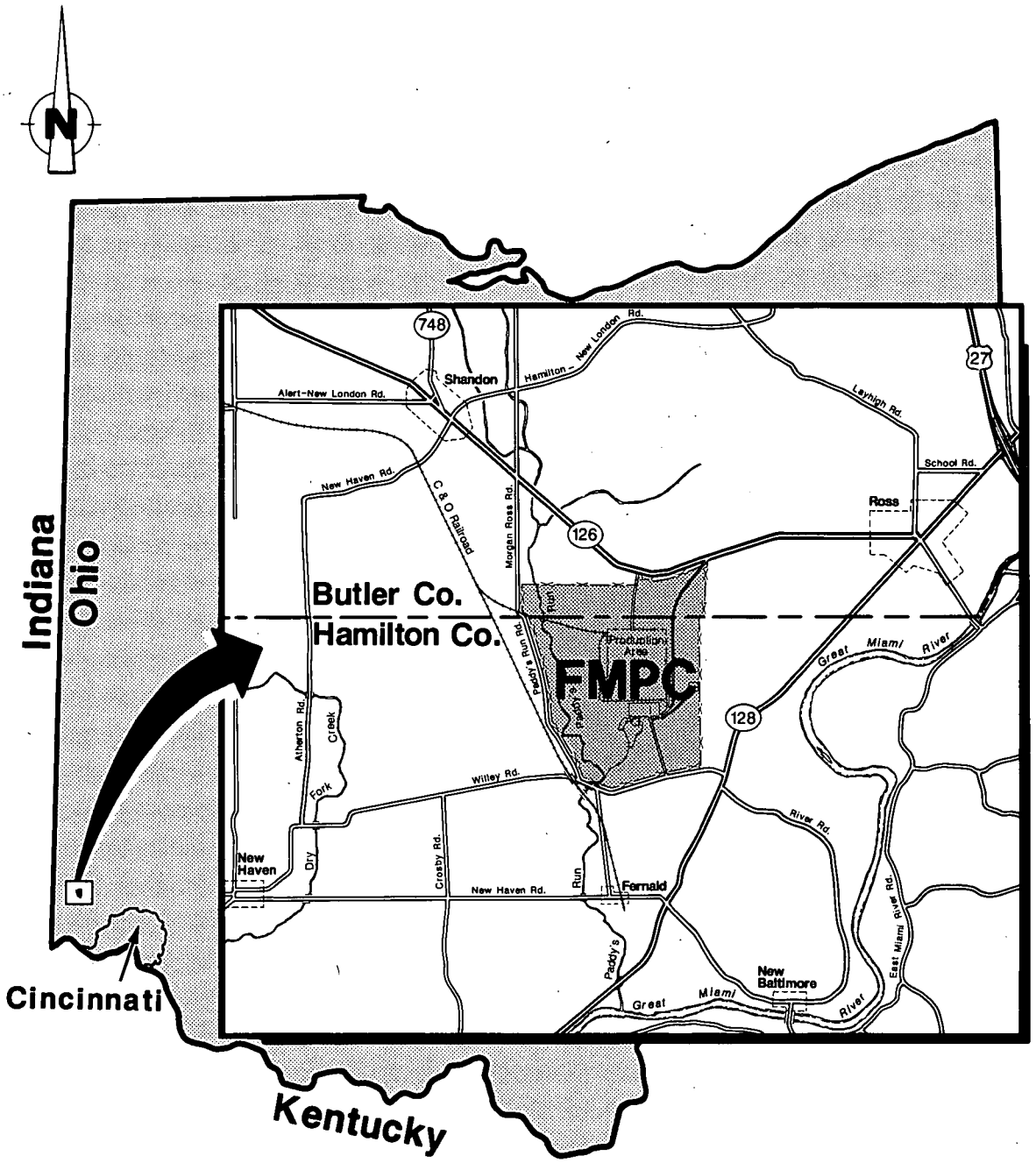
In general, the relative importance and corresponding funding of the FMPC's production and environmental activities reflect the course of events in the United States from the end of World War II until today. Uranium-metal production reached a peak during the height of the Cold War during the 1950s and 1960s. Federal and state waste management requirements were applied, but they were not as stringent as they are today.

Funding for FMPC production and supporting organizations, including environmental monitoring, was significantly reduced during the late 1970s. The site nearly closed. But, during the early 1980s, the U.S. increased defense spending and production at the FMPC accelerated. At the same time, there was an increase in the number and stringency of environmental regulations. By the late 1980s, this increasing demand for environmental accountability, combined with a decreasing demand for uranium metal by other DOE facilities, influenced the FMPC to change its mission.

As a result of the change in mission, the FMPC greatly expanded its environmental training programs. The training focuses on several areas, including:

- Environmental regulations which affect operations at the FMPC,

FIGURE 1: FMPC and Vicinity



The FMPC covers about 425 hectares (1,050 acres).

1302

- Handling, storing, and transporting hazardous waste as regulated by the Resource Conservation and Recovery Act (RCRA), and
- General or occasional worker requirements specified in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Superfund Amendment and Reauthorization Act (SARA), and RCRA.[1]

By the end of March 1991, 80% of the FMPC workforce was devoted to performing waste cleanup and environmental management tasks, and had been trained according to Occupational Safety and Health Act (OSHA), United States Environmental Protection Agency (USEPA), Department of Transportation (DOT), state laws, DOE regulations and orders, and FMPC health and safety standards and operating policies and procedures.

Today, the FMPC continues to investigate the effects that its years of operation had on the environment. The Environmental Monitoring Program plays a key role in this effort. Like any complex program or investigation, the Environmental Monitoring Program was developed after careful consideration of many components. For example, FMPC production processes, which involved both radioactive and nonradioactive materials, resulted in air and liquid discharges to the environment. The monitoring program is largely based upon the flow of these materials through the air and liquid pathways. Furthermore, the program is regularly modified to reflect changing conditions.

An Overview of Production Operations

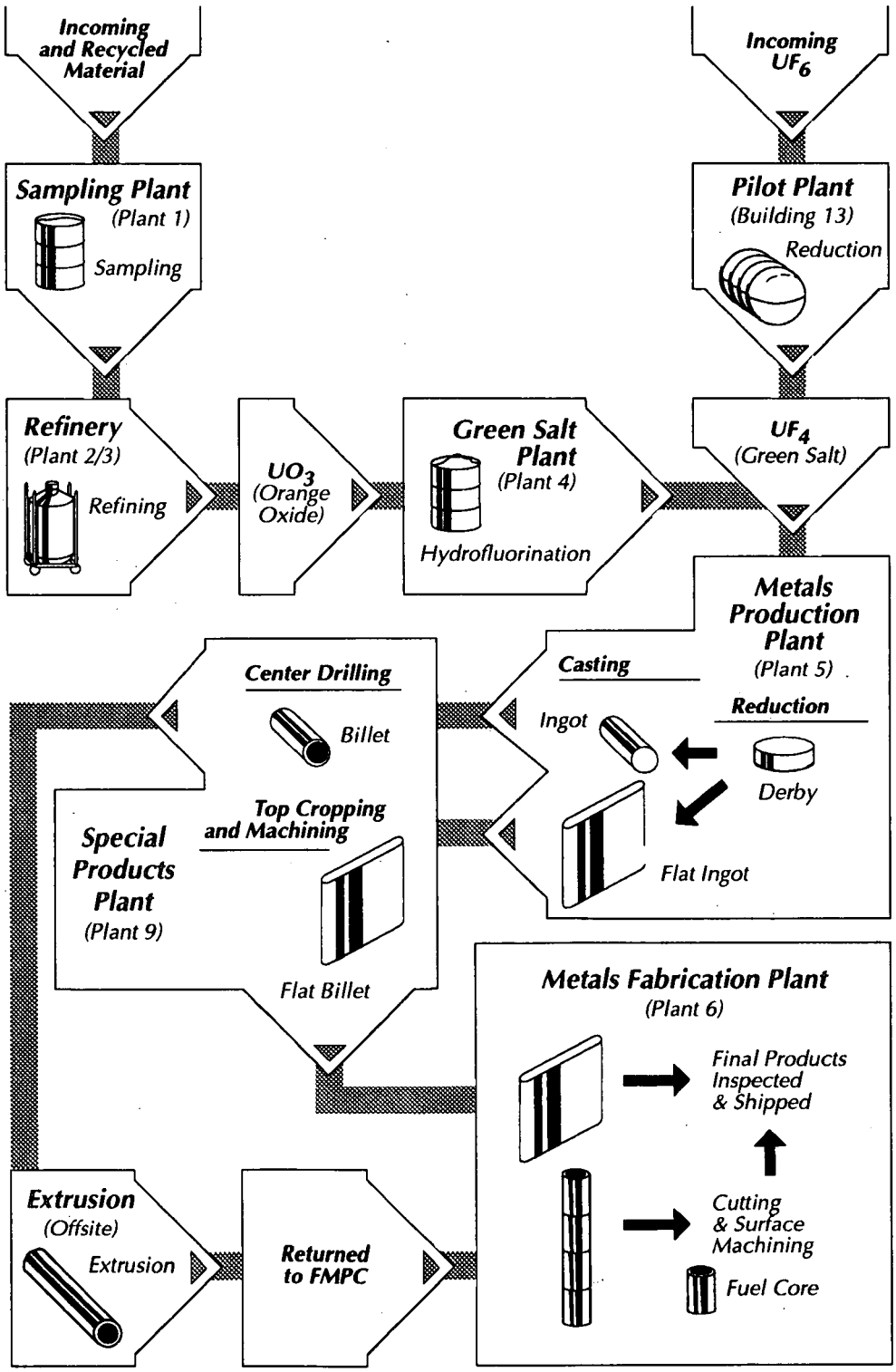
Even though production has ended, an examination of the production process is necessary in order to understand the basis for the ongoing Environmental Monitoring Program and other environmental investigations. The major steps in the production process are highlighted in Figure 2. Figure 3 is a perspective of the site. A variety of materials were used in the process, including many that were received from other DOE sites. In fact, materials such as floor sweepings and dust collector and production residues were recycled in order to recover as much of the uranium as possible.

Most of the uranium processed in recent years at the FMPC was depleted in the uranium-235 isotope, that is, it contained a smaller percentage of uranium-235 than does naturally occurring uranium — less than 0.71%. (Isotopes are discussed in Chapter Three, Fundamentals of Radiation.) For many years, much of the uranium processed was slightly enriched (greater than 0.71% uranium-235) to no more than 2% uranium-235.

The first production steps involved chemical processing that ended with an intermediate product commonly called green salt (uranium tetrafluoride, UF_4). The green salt was then blended with magnesium-metal granules, placed in a closed reduction pot, and heated in furnaces in Plant 5. The product from this operation was uranium metal called a derby.

(Text continues on page 8.)

FIGURE 2: FMPC Production Process



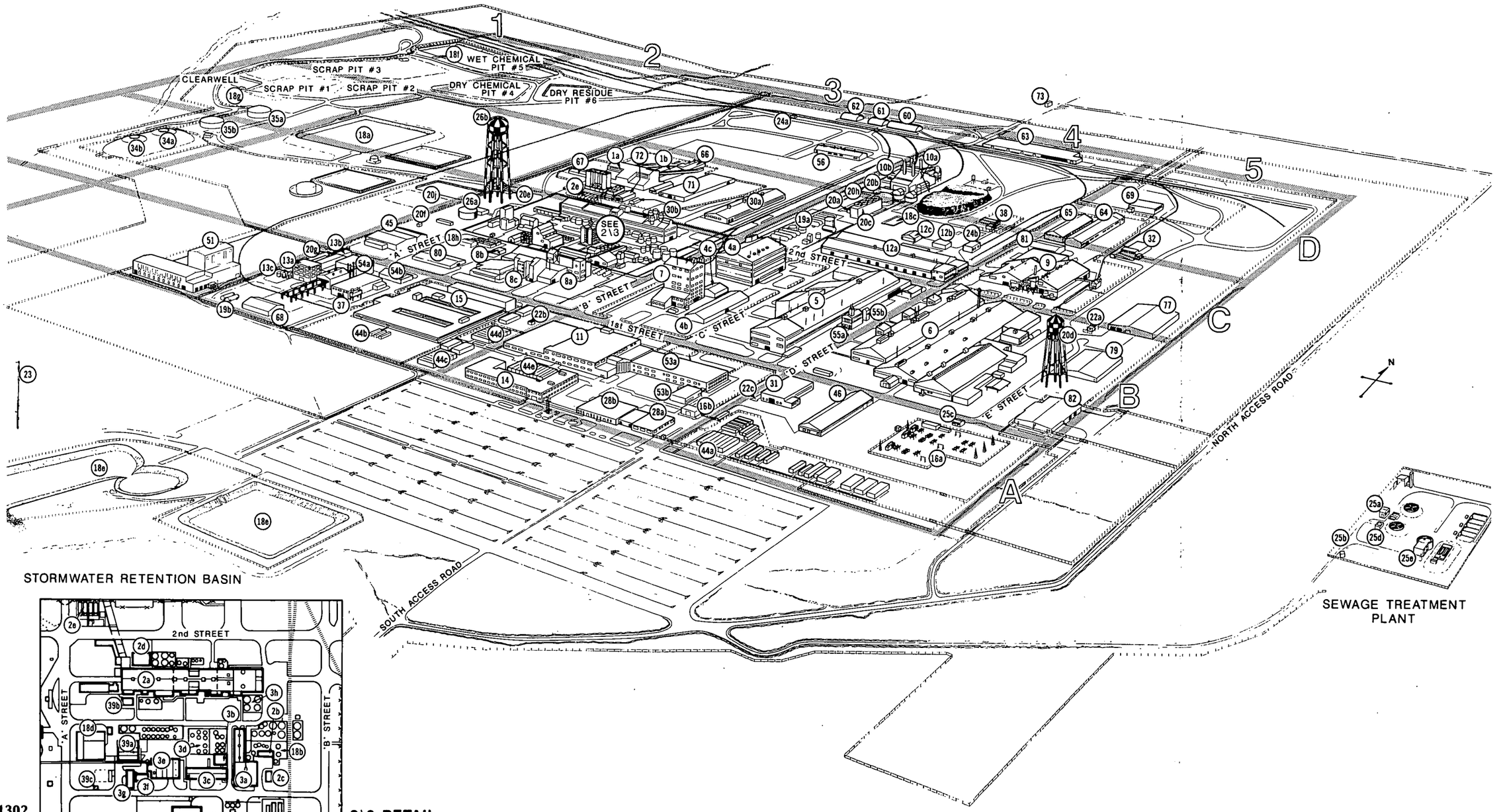
Building Identification

Building ID No.	Grid Coordinates	Title
00	**	General
1a	C-3	Preparation Plant
1b	C-3	Plant 1 Storage Building
2a	B-3	Ore Refinery Plant
2b	B-3	Lime Handling Building
2c	B-3	Bulk Lime Handling Building
2d	B-3	Metal Dissolver Building
2e	C-3	NFS Storage and Pump House
3a	B-3	Maintenance Building
3b	B-3	Ozone Building
3c	B-3	Control House
3d	B-3	NAR Towers
3e	B-3	Hot Raffinate Building
3f	B-3	Digestion Fume Recovery
3g	B-3	Refrigeration Building
3h	B-3	Refinery Sump
4a	B-4	Green Salt Plant
4b	B-4	Plant 4 Warehouse
4c	B-4	Plant 4 Maintenance Building
5	B-4	Metals Production Plant
6	B-5	Metals Fabrication Plant
7	B-4	Plant 7
8a	B-3	Recovery Plant
8b	B-3	Maintenance Building
8c	B-3	Rotary Kiln/Drum Reconditioning
9	C-5	Special Products Plant
10a	D-4	Boiler Plant
10b	D-4	Boiler Plant Maintenance Building
11	A-4	Service Building
12a	C-4	Maintenance Building (Main)
12b	C-4	Cylinder Storage Building
12c	C-4	Lumber Storage Building
13a	A-3	Pilot Plant Wet Side
13b	A-3	Pilot Plant Maintenance Building
13c	A-3	Sump Pump House
14	A-4	Administration Building
15	A-3	Laboratories
16a	A-5	Main Electrical Station
16b	A-4	Electrical Substation
18a	C-2	Biodenitrification Surge Lagoon
18b	B-3	General Sump
18c	C-4	Coal Pile Runoff Basin
18d	B-3	Biodenitrification Towers
18e	*	Stormwater Retention Basin
18f	D-1	Pit 5 Sluice Gate
18g	C-1	Clearwell Pump House
18h	B-3	BDN Effluent Treatment Facility
19a	C-4	Main Metal Tank Farm
19b	A-3	Pilot Plant Ammonia Tank Farm
20a	C-4	Valve/Control Building
20b	D-4	Filter/Chemical Building
20c	C-4	Cooling Towers
20d	B-5	Elevated Storage Tank (Potable H_20)
20e	B-3	Well House #1
20f	B-3	Well House #2
20g	A-3	Well House #3
20h	D-4	Process Water Storage Tank
20j	B-2	Lime Slurry Pits
22a	B-5	Gas Meter Building
22b	A-3	Stormsewer Lift Station
22c	A-5	Truck Scale
23	*	Meteorological Tower
24a	D-3	Railroad Scale House
24b	C-4	Railroad Engine Building
25a	*	Chlorination Building
25b	*	Manhole-175
25c	A-5	Sewage Lift Station Building
25d	*	U.V. Disinfection Building
25e	*	Digester Control Building
26a	B-3	Pump House- H.P. Fire Protection
26b	B-3	Elevated Water Storage Tank
28a	A-4	Security Building
28b	A 4	Human Resources Building
30a	C-3	Chemical Warehouse
30b	C-3	Drum Storage Warehouse
31	A-5	Engine House - Garage
32	D-5	Magnesium Storage
34a	B-1	K-65 Storage Tank - North
34b	B-1	K-65 Storage Tank - South
35a	C-1	Metal Oxide Storage Tank - North
35b	B-1	Metal Oxide Storage Tank - South
37	A-3	Pilot Plant Annex
38	D-4	Propane Storage
39a	B-3	Incinerator Building
39b	B-3	Shelter Storage Building
39c	B-3	Incinerator Building Sprinkler Riser House
44a	A-5	Trailer Complex - 6-Plex - East
44c	A-3	Trailer Complex - 7-Plex - South
44d	A-3	Trailer Complex - 7-Plex - North
44e	A-4	Trailer Complex - 10-Plex
45	B-3	Rust Engineering Building
46	A-5	Heavy Equipment Garage
51	A-2	UF_6 to UF_4 Reduction Facility 11
53a	A-4	Occupational Safety & Health
53b	A-4	In-Vivo Building
54a	A-3	UF_6 to UF_4 Reduction Facility I
54b	A-3	Pilot Plant Warehouse
55a	B-4	Slag Recycling Plant
55b	B-4	Slag Recycling Pit/Elevator
56	D-3	CP Storage Warehouse
60	D-3	Quonset Hut #1
61	D-3	Quonset Hut #2
62	D-3	Quonset Hut #3
63	D-4	KC-2 Warehouse
64	D-5	Thorium Warehouse
65	D-5	(Old) Plant 5 Warehouse
66	C-3	Drum Reconditioning Building
67	C-3	Plant 1 Thorium Warehouse
68	A-3	Pilot Plant Warehouse
69	D-5	Decontamination Building
71	C-3	General In-Process Storage Warehouse
72	C-3	Drum Storage Building
73	*	Fire Brigade Training Center Building
77	C-5	Finished Products Warehouse
78	*	New D&D Facility
79	B-5	Plant 6 Warehouse
80	B-3	Plant 8 Warehouse
81	C-5	Plant 9 Warehouse
82	B-5	Receiving & Incoming Materials Inspection Area

* Outside of Perimeter Security Fence

** NOTE: Any Unidentified Area is Referred to as 00 General

FIGURE 3: FMPC Site Perspective



2\3 DETAIL

Some derbies were sent directly to other DOE sites, while the remainder were remelted, along with uranium scrap-metal recovered from earlier production, and poured into graphite molds to form ingots. Ingots varied in weight, size, and shape according to how they were used at the FMPC and at other DOE sites. Machining of these ingots occurred in Plants 6 and 9, after which the billets (machined ingots) were shipped to other DOE sites, principally Savannah River and Richland.

Handling and Storing Radioactive and Hazardous Materials

Although the FMPC no longer produces uranium metal, the site continues to store materials once used here and at other DOE sites. The Environmental Monitoring Program samples the air and liquid pathways, since these materials can affect the environment if they are released. Some of the radioactive and hazardous materials handled or stored onsite during 1990 included:

Radioactive

- Pitchblende ore residues containing radium stored in the K-65 Silos,
- Thorium and thorium compounds stored in several locations within the production area,
- Radioactive materials in the waste pits,
- Uranium metal,
- Uranium compounds,
- Magnesium fluoride (MgF_2) contaminated with uranium, and
- Scrap metal contaminated with uranium compounds.

Hazardous

- Nitric acid,
- Laboratory chemicals,
- Hydrochloric acid,
- Sulfuric acid,
- Methanol, and
- Process waste.

The FMPC is refurbishing and adding buildings to store hazardous waste, repackaging some materials into new drums, and removing materials no longer needed since production has ended. For example, two new warehouses originally built to store uranium products have been converted to meet the requirements for hazardous waste storage. Also, thorium previously stored in a deteriorating above-ground silo, in bins, and and in drums on an outdoor pad were repackaged in new drums and

stored in a warehouse. The FMPC has significantly reduced its inventory of chemicals once used for production by removing them from the site.

Purpose of the Environmental Monitoring Program

The FMPC engages in a broad range of environmental monitoring activities to determine the amount of radioactive and nonradioactive materials that leave the site and enter the surrounding environment. During 1990, Environmental Monitoring personnel collected more than 2,570 samples of air, soil, groundwater from private wells, sediments, produce, and other environmental media, and over 4,600 analyses were performed. The year-round Environmental Monitoring Program is designed to:

- Ensure that the FMPC can detect any unusual release of materials as quickly as possible so that corrective actions can be implemented,
- Closely monitor releases to ensure that air emission and liquid effluent standards and guidelines are not exceeded,
- Evaluate the impact of operations (past and present) on the environment,
- Estimate the radiation dose that area residents may be exposed to as a result of former production operations and current cleanup activities at the site, and
- Measure progress in correcting problems from past operations and in implementing improved environmental management practices.

This Annual Environmental Report (AER) focuses on the results of the ongoing FMPC Environmental Monitoring Program, reports summary data of the sampling the FMPC conducts to detect if the site complies with DOE, USEPA, and Ohio Environmental Protection Agency (OEPA) requirements, and provides general information on the major waste management and environmental restoration activities during 1990. The AER presents information according to requirements stated in DOE Order 5400.1, and has been published for the FMPC since 1960.[2] The AER is not required under CERCLA regulations.

In previous years, this report was known as the Environmental Monitoring Report (EMR). Recently, however, the report has included additional information on environmental issues and projects, in areas not directly related to the Environmental Monitoring Program. To reflect the expanded environmental program, this report is now called the Annual Environmental Report. While the report concentrates on the Environmental Monitoring Program, it does include information on the RI/FS being conducted at the FMPC.

Local Geography

To improve our understanding of the effects of former production operations on the surrounding environment, it is essential that the FMPC explore the physical and ecological characteristics of the area. This knowledge helps scientists and engineers focus on remedial techniques best suited for the area. The following sections describe several of these characteristics, beginning with the geologic origins of the area.

Geologic History

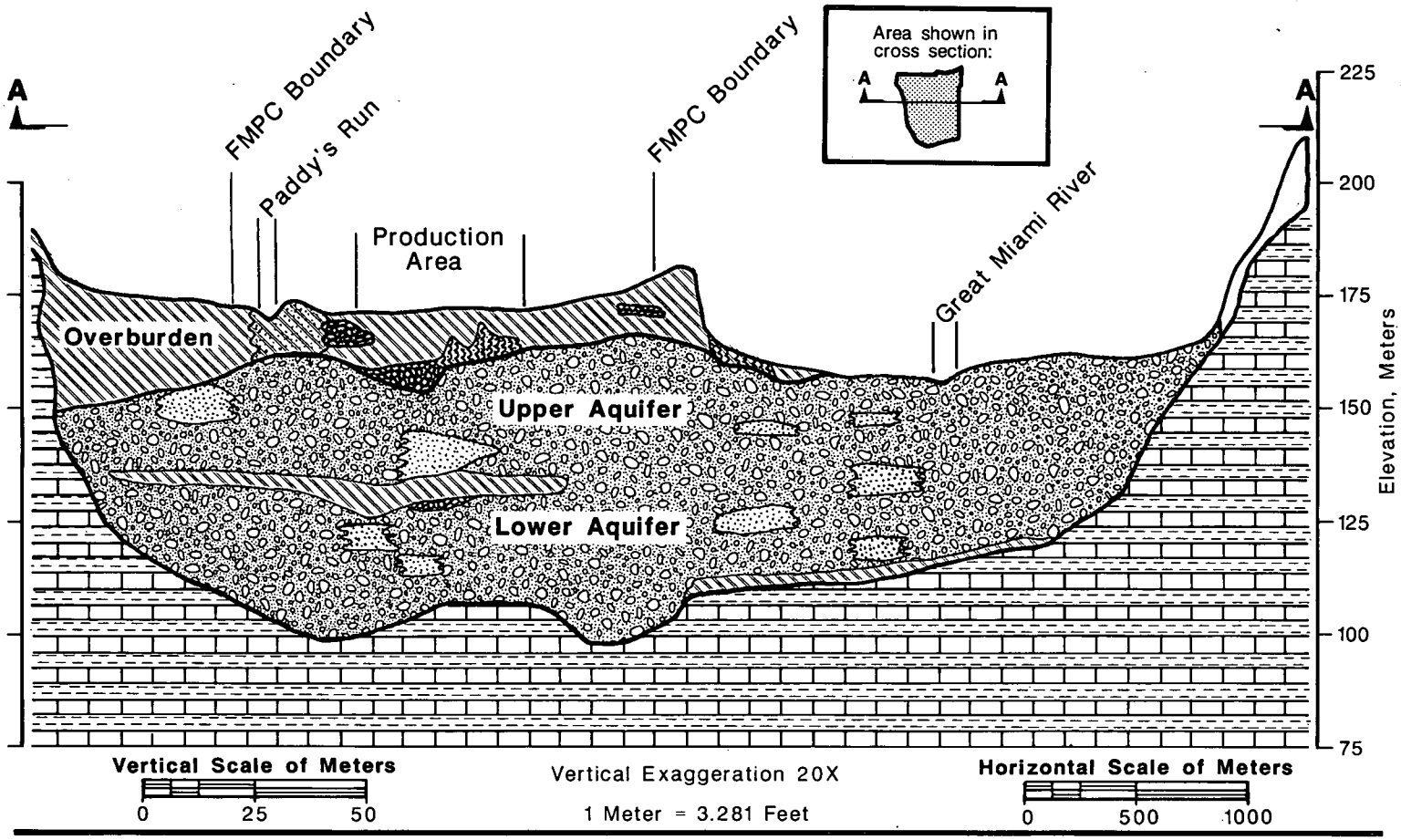
About 450 million years ago (in Late Ordovician time), sediments were deposited in a shallow sea. These sediments hardened over time to become predominantly shale with alternating thin layers of limestone, strata known universally as the Cincinnatian Series. This Cincinnatian shale is the relatively impermeable bedrock underlying the FMPC site.

An ancient river, larger than the present-day Great Miami River, cut into the shale bedrock to about 60 meters (200 feet) below the present-day river, forming a channel named the New Haven Trough. Later, the Illinoisan and Wisconsin glaciers (about 40,000 years ago and 10,000 years ago, respectively) advanced into the area during Pleistocene glaciation. These glaciers crushed rocks as the ice moved southward from the arctic region. As the glaciers retreated, they melted, filling the trough with sand and gravel sediments.[3]

The last of the glaciers in the FMPC area deposited a relatively impermeable *glacial till* over the sands and gravels. A mix of clay, silt, sand, gravel, and boulders, this glacial till is unevenly deposited throughout the area and makes up the local *overburden.*

The Great Miami River and its tributaries have eroded significant portions of the overburden and left *terrace remnants* which stand higher than surrounding bottom lands of the river valley. The FMPC site lies on top of one of these terrace remnants, about 177 meters (580 ft) above sea level. The FMPC property rises to 213 meters (698 ft) at the northern boundary of the site, and slopes downward to 168 meters (551 ft) at Paddy's Run. North and south-southwest of the site are hills that peak about 260 meters (850 ft) and 235 meters (770 ft), respectively. The elevation of the Great Miami River, east of the FMPC, is about 165 meters (540 ft), while the land rises gently to about 183 meters (600 ft) west of the site. Figure 4 presents a cross section of the FMPC area.

FIGURE 4: Cross-Section of the New Haven Trough, Looking North



Lithology

The studying, classifying, and mapping of rocks and rock formations, called *lithology*, is vital in determining where groundwater exists, how it moves, and where it is moving. The shale underlying the FMPC forms the floor and valley walls of the New Haven Trough, and is generally between 18 and 60 meters (60 to 200 feet) below the ground surface. The elevation of the bedrock surface varies from 100 meters (330 feet) above sea level south of the production area, to 122 meters (400 feet) just north of the FMPC.[4]

Sand and gravel filling the New Haven Trough is up to 60 meters (200 feet) thick. This relatively porous material makes up the Great Miami Aquifer. Underneath parts of the FMPC, about 30 to 38 meters (100 to 125 feet) below the surface, the sand and gravel is divided by a greenish-black silty clay layer, about three to six meters (10 to 20 feet) thick.[4, 5] Data collected as part of the ongoing RI/FS suggest that the clay layer extends from west of Paddy's Run to the center of the production area, and is present beneath the waste pit area. The clay layer does not extend east or south of the production area.

The dense, silty-clay, glacial till overlies the sand and gravel aquifer. This overburden varies in composition both vertically and horizontally, and ranges in thickness between six and 15 meters (20 to 50 feet). The elevation of the base of the overburden is 165 meters (540 feet) above sea level.[4, 5, 6] The silty-clay overburden remains continuous north and east of the site and rests upon the shale bedrock in these areas.

West and south of the FMPC, the silty-clay overburden thins and becomes silty-sand and silt. In the lower reaches of Paddy's Run and the outfall ditch, the silty-clay has eroded, exposing the underlying sand and gravel and allowing the aquifer direct contact with surface runoff.

Groundwater Hydrology

In order to understand how water moves through the environment, scientists study the *hydrology* of an area. Hydrology is the study of the properties, distribution, and circulation of water in the environment. Surface hydrology, discussed in the next section, studies drainage systems like rivers, streams, and the runoff of rainwater. Groundwater hydrology, discussed here, focuses on the movement of water below the earth's surface.

Groundwater beneath the FMPC occurs as perched water in the glacial overburden, in a sand and gravel aquifer, and, to a much lesser extent, in the underlying bedrock. Perched water occurs when water sinking

through the earth from the surface is trapped above very dense clay. Some of this perched water may slowly seep through the clay, but most remains trapped. At the FMPC, perched water is generally found between 0.3 and 3 meters (1 to 10 feet) below the surface. Perched water in the glacial overburden occurs sporadically and is usually not a sufficient source of drinking water.

Water sinking through the glacial overburden quickly collects in the sand and gravel aquifer, saturating it. Most water is prevented from sinking farther by the nearly impermeable rock floor. The top of the aquifer is about 25 meters (82 feet) beneath the FMPC, and the aquifer is between 38 to 53 meters (125 to 175 feet) thick. As shown in Figure 5, the groundwater in the sand and gravel aquifer is moving east under the waste pit and production areas, while on the southern edge of the facility groundwater moves to the south. These groundwater flow data are used to track and forecast the movement of contaminants which may be found in the aquifer.

There may be groundwater even deeper in the slightly permeable rock layers below the sand and gravel aquifer; however, this water is essentially trapped in cracks and fissures and does not contribute any significant amount to the entire flow system.

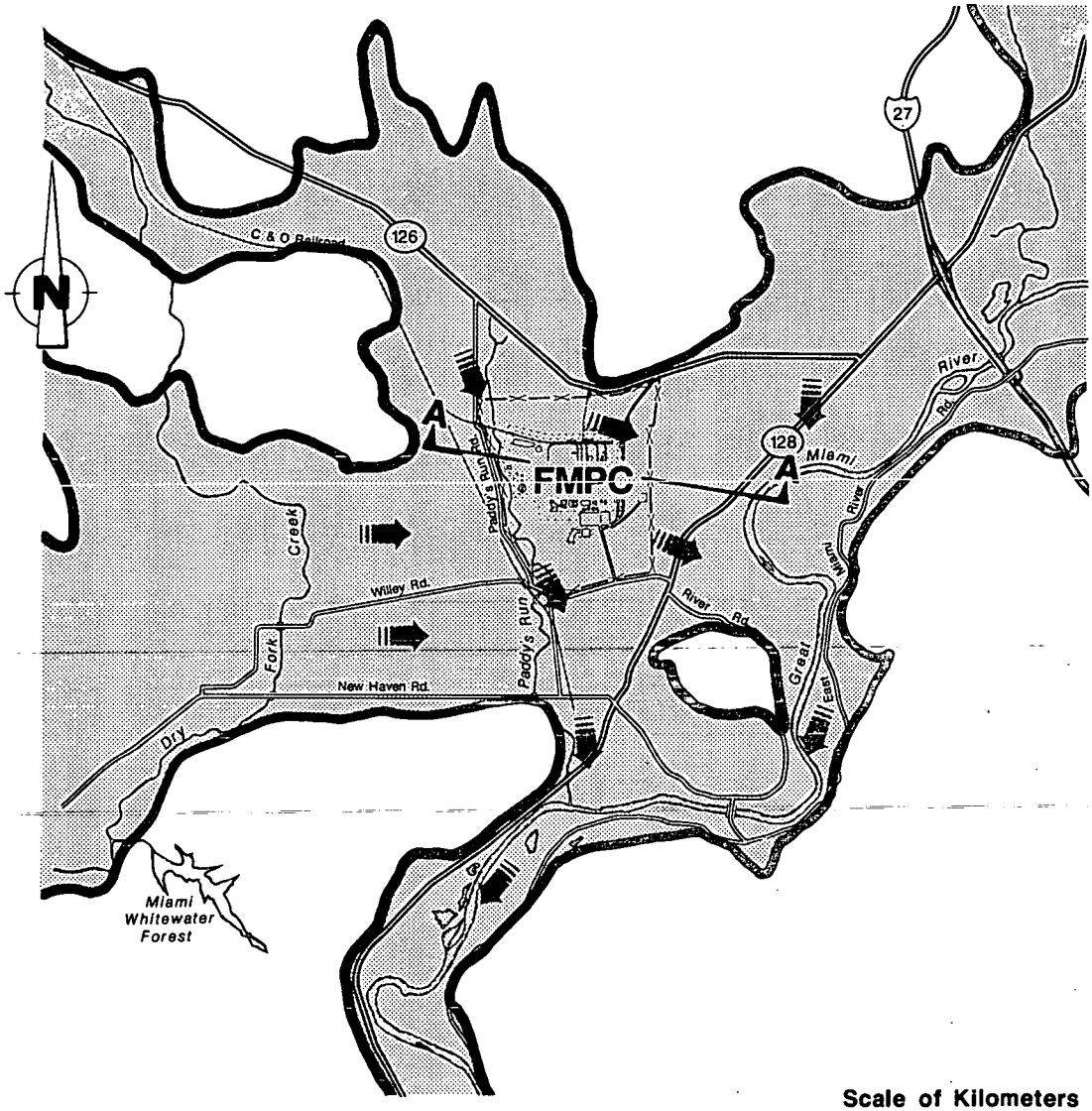
Groundwater does not move in the overburden as easily as it flows in the sand and gravel aquifer. In addition, flow directions are not as uniform in the overburden as in the sand and gravel aquifer because most perched water occurs in isolated pockets.[7]

Surface Hydrology

The FMPC is located within the Great Miami River drainage system, above the river's present-day floodplain. Natural drainage from the FMPC to the Great Miami River is primarily via Paddy's Run. Paddy's Run is a small creek which begins north of the FMPC and flows southward along the western edge of the site. This intermittent stream begins losing flow to the underlying sand and gravel aquifer south of the waste pit area. About 2.4 km (1.5 miles) south of the site, Paddy's Run flows into the river. Some of the surface water drainage from the FMPC site is now channeled away from Paddy's Run into a retention basin.

The Great Miami River, located about 1 km (0.6 miles) east and south of the FMPC, runs in a southerly direction. Upstream of the FMPC on the Great Miami River lie the communities of Fairfield, Hamilton, Middletown, and Dayton (Figure 6). Downstream areas are sparsely populated and have a few small industries. The Great Miami River flows into the Ohio River about 39 km (24 miles) downstream of the FMPC.

FIGURE 5: Buried Valley Aquifer Underlying the FMPC and Vicinity



LEGEND

- Buried Channel Aquifer
- General Direction of Groundwater Flow
- Plant Perimeter
- A A Location of Cross Section Shown in Figure 3.1

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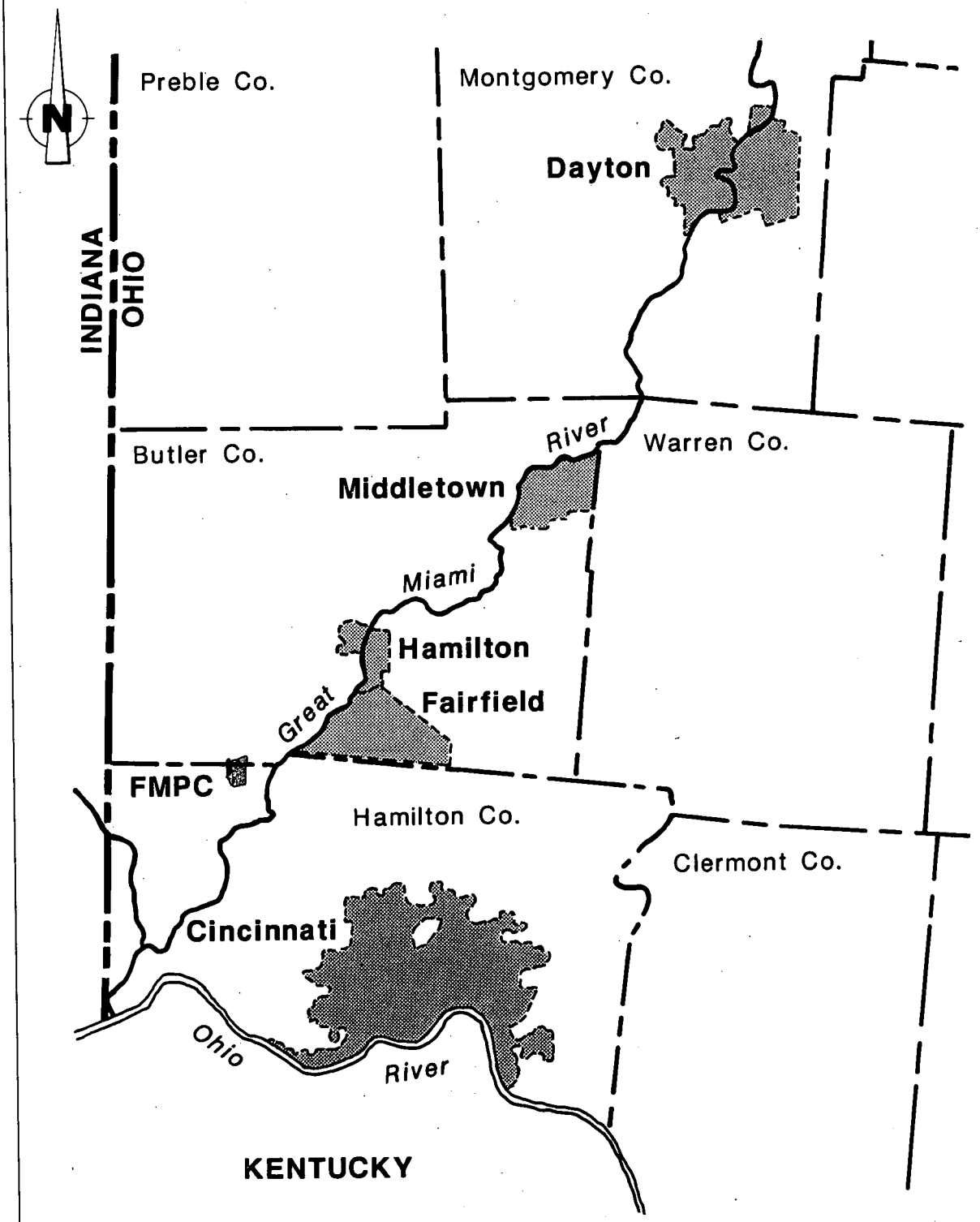
FIGURE 6: Major Communities in Southwestern Ohio



The river is not a source of public drinking water between the FMPC and the Ohio River. Although the Great Miami River is considered unsafe for swimming due to turbulence, some people do fish there.

A daily record of the river flow is made at river mile 34.8 near the city of Hamilton, Ohio. This is about 10 miles upstream of the FMPC effluent line. The minimum flow during 1990, 17.6 cms (620 cfs), was recorded on December 28 and 29; the maximum flow, 1,087.5 cms (38,400 cfs), was recorded on May 17; the average flow for 1990 was 164.0 cms (5,791 cfs). The estimated annual flows at Ross, Ohio (about river mile 26) and at New Baltimore, Ohio (about river mile 21) were 172.0 cms (6,072 cfs) and 172.6 cms (6,094 cfs), respectively.[8]

Biology

The plants found at the FMPC are typical of southwestern Ohio and consist of a variety of grasses and brush. Wooded and wetland areas also exist. The area north of the production area is moderately wooded with a variety of deciduous hardwoods. Pine trees were planted on several acres immediately north of the production area as part of an environmental improvement project in 1973. Naturally wooded areas are also found in watersheds along Paddy's Run. Much of the remainder of the site is leased to local dairy producers whose cattle graze on a variety of pasture grasses. Grasses and brush dominate the waste storage area.

This plant diversity provides abundant food and cover for wildlife, including eastern cottontails, woodchucks and pheasants. The pine trees provide cover for deer and other animals and also provide nesting areas for various species of birds, such as song sparrows, blue jays, cardinals, and robins.

White-tailed deer, bobwhite quail, assorted waterfowl, and other game species have been observed onsite. Paddy's Run provides habitat for several species of fish, including minnows, darters, and shiners.

Several professors from Miami University (Oxford, Ohio) began a comprehensive biological and ecological study of the FMPC in 1986. They surveyed the plants and animals found at the FMPC to try to determine if any species were being stressed by the operations at the site. Based on statistical analyses, the study revealed that the FMPC's impact on the natural habitat was not different than the impact other local industrial sites have on the environment. The only variations were the slightly smaller-than-normal size of robin and dove nestlings and the presence of a rare, inactive group of genes in treefrogs. Their report, published in January 1990, concludes that no plants or animals found at the FMPC were on the federal endangered species list.[9]

Miami University continued the studies of robins and treefrogs during 1990.[10, 11] Both of these studies were inconclusive, and research in these areas will continue during 1991.

Miami University conducted an additional study during 1987 to examine the population genetics of periodical cicada (17-year emergence) collected at the FMPC. Though cicada spend most of their life in the soil, the results of the study indicate that soil contaminants at the FMPC did not alter the population genetics of the cicada. The report was published in March 1991.[12]

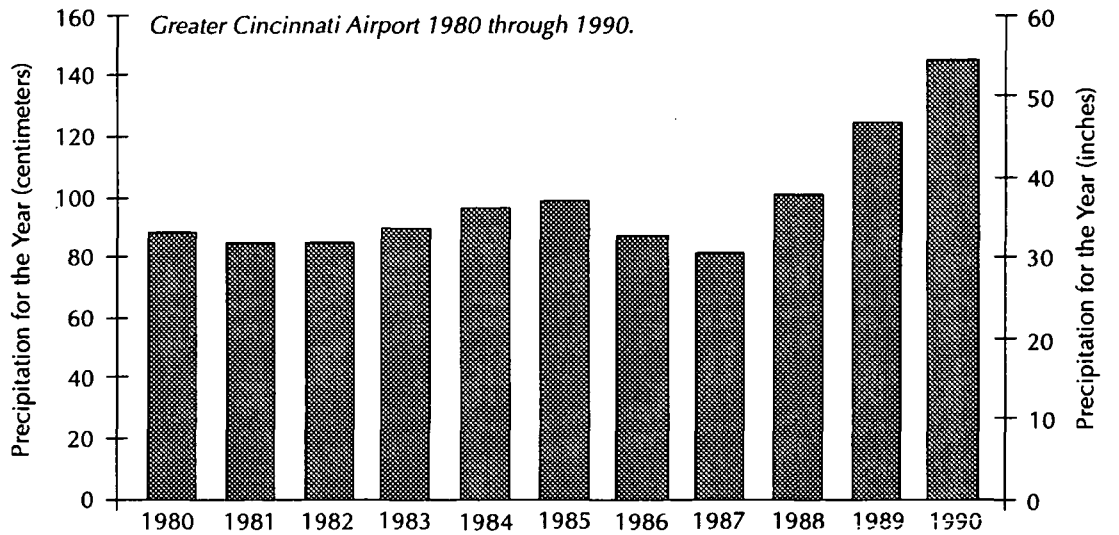
Meteorology

The FMPC installed an onsite meteorological monitoring system in August 1986. The system includes a meteorological tower, monitoring instruments, a data logger, and a computer. The tower instruments measure wind speed and direction, ambient air temperature, lapse rate (a measure of atmospheric stability), dewpoint temperature, barometric pressure, sigma theta (the standard deviation of horizontal wind direction over time and also a measure of atmospheric stability), and precipitation. Before the tower was installed, and at times when the onsite meteorological system was not operating, the FMPC obtained its meteorological data from the Greater Cincinnati International Airport, located about 27 km (17 miles) south of the site.

The meteorological monitoring system had a 70% data recovery rate for 1990. System downtime occurred primarily during maintenance and calibration periods. The FMPC is considering additional training for personnel as one way to improve data recovery during 1991.

Because of the relatively low data recovery for the onsite system, precipitation data for 1990 for the entire year were from the Greater Cincinnati International Airport. The total rainfall in 1990 was 146 cm (57.6 inches), considerably above the average rainfall of 104.5 cm (41.13 inches) for 1960 through 1990. The wettest month during 1990 was May when 23.9 cm (9.4 inches) fell. By contrast, the least precipitation was recorded in November when 5.9 cm (2.3 inches) fell. Figure 7 presents precipitation data for 1980 through 1990.

FIGURE 7: Annual Precipitation Data, 1980 to 1990



Economy

The major economic activities in the local communities rely heavily on the physical environment. Farming and raising dairy and beef cattle account for the majority of the land use in the area. Major crops include field corn, sweet corn, soybeans, and winter wheat. Several nearby farms also sell produce locally or in nearby urban markets.

Other important commercial products from the area include sand, gravel, and water from the aquifer. Many gravel-pit operations exist along the Great Miami River and some distance inland. A water company is located 2 km (1.25 miles) upstream of the FMPC discharge line (outfall) to the river. Presently, this company pumps about 76,000 m^3 (20 million gallons) of groundwater per day, which it sells chiefly to industries in Greater Cincinnati.

Exposure Pathways to Humans

To protect this local environment, the Environmental Monitoring Program focuses on exposure pathways. A pathway is a route by which materials could travel between the point of release and point of delivering a radiation or chemical dose to a person. Pollutants may reach people directly as contaminated air or water, or through several secondary pathways, as through a food chain. One example of a secondary pathway is the air-to-soil-to-roots-to-produce-to-human pathway. In this scenario, a gas or dust, released from a production stack, settles on a field or a plant and is absorbed into the soil. A plant may also absorb the pollutant through its roots and into the rest of the plant, including the edible portions.

This scenario presents a simplified pathway that materials may take. The actual route of the material can be very complex and the quantity of material that could eventually reach people is very small. To develop an understanding of the complexity, take another look at the pathway and consider that not all materials released settle out of the air; some fraction may be washed out by rain and enter surface water or groundwater. Of the fraction that does settle, not all falls onto fields, and not all of that fraction on fields is absorbed by the roots of plants. This process of dilution and separation continues until some small fraction of what is released in the air may reach the leaves or fruit of the plant. Although certain plants, animals, and soils may concentrate specific materials and are therefore important points in pathways that should be sampled, pathways frequently overlap and it is difficult to trace them precisely. Environmental sampling and analysis are performed to detect the presence and concentration of pollutants throughout the air and liquid pathways.

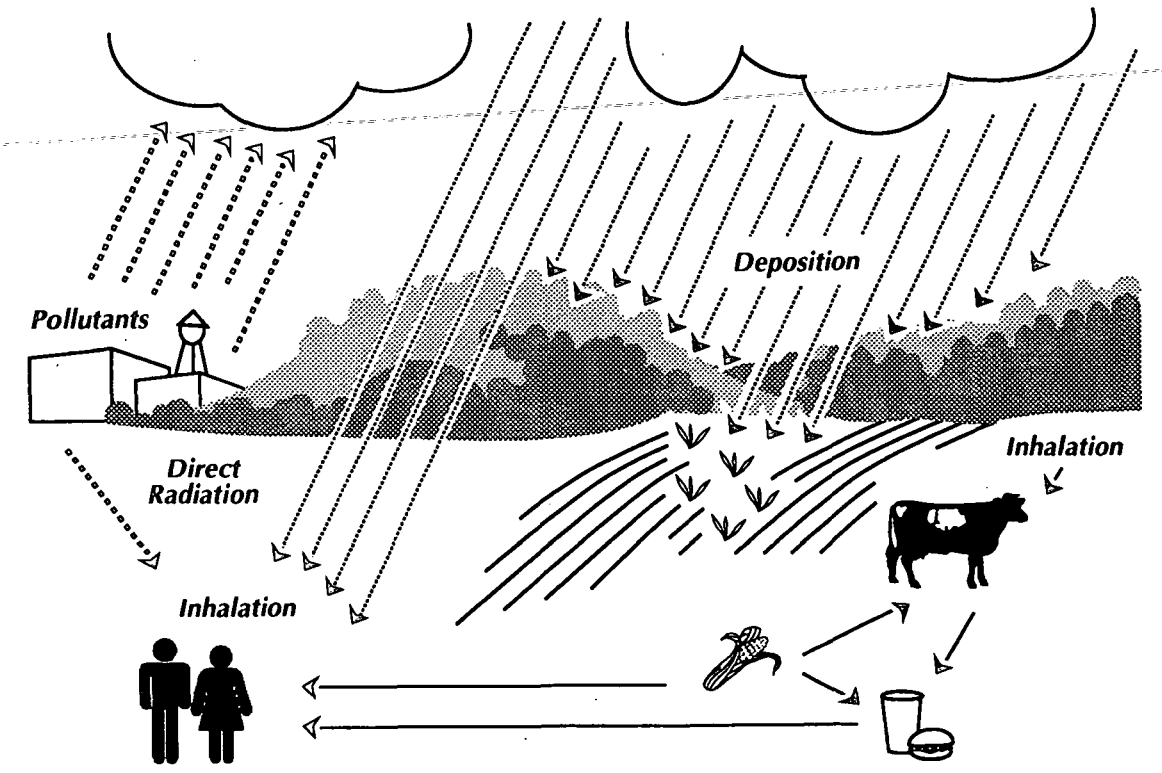
Although both radioactive and nonradioactive materials can reach people through the same pathways, the pathway scenarios presented here and throughout the AER will focus on radioactive contamination since this is of primary concern at the FMPC. Much of this report, and the nucleus of the Environmental Monitoring Program, focuses on radioactive contamination. Uranium is the major radioactive pollutant at the FMPC; however, some of the uranium processed was recycled from nuclear reactors and contains trace concentrations of fission products (such as strontium-90 and cesium-137) and transuranics (such as neptunium-237, plutonium-239, and plutonium-240). These fission products are radioactive, and the FMPC monitors for them as well in air and liquid discharges to the environment. These trace radionuclides also exist in the environment as a result of fallout from weapons testing and emissions from other nuclear facilities.

To organize the many pathways that exist, the Environmental Monitoring Program centers on two major pathways: air and liquid. These pathways provide a basis for the FMPC environmental sampling program and direct which environmental samples and models will be used in estimating dose. (Direct radiation, a third pathway, is monitored with radiation detection instruments that measure radiation emitted directly from the site, particularly from the K-65 Silos. Direct radiation is discussed further in Chapter Seven.) The following sections describe how materials from the FMPC may follow the air and liquid pathways and briefly describe Environmental Monitoring procedures.

Air Pathway

The air pathway includes all the airborne pollutants that may be carried from the FMPC through emissions and also includes direct radiation (Figure 8). Stack and building vent emissions are obvious sources of pollutants, but dust from construction and remediation activities, waste handling, and wind erosion are also important potential sources. The form and chemical makeup of pollutants influence how they are dispersed in the environment as well as how they may deliver radiation doses. For example, fine particles and gases are breathed in, while larger,

FIGURE 8: General Air Pathways to People

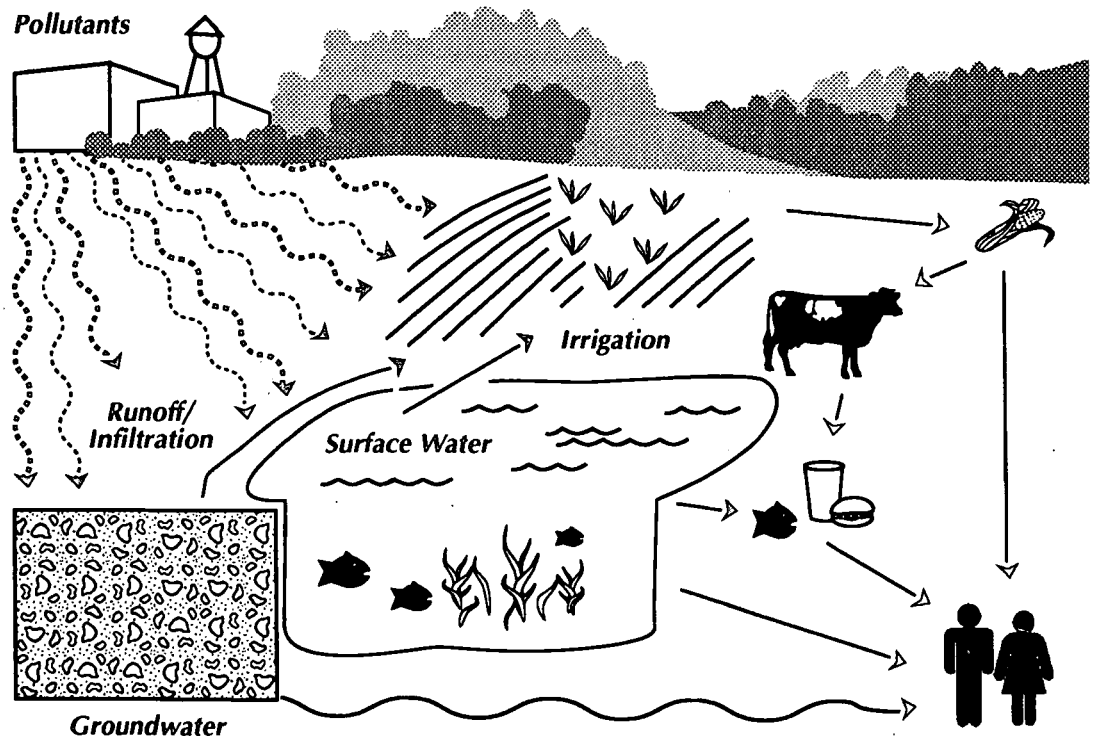


heavier particles tend to settle and deposit on grass or soil. Chemical properties determine whether the pollutant will dissolve in water, be absorbed by plants and animals, or settle in sediments and soils.

For the environmental scientist, the first step in monitoring the air pathway is measuring the concentration of the pollutants at the point of release, after they have gone through treatments and filtering. This provides preliminary information on how much pollutant is released and how it will behave in the environment. It is also possible to estimate the concentration of contaminants in the air once the emissions pass through the stack. The FMPC operated 16 air monitoring stations 24 hours a day, seven days a week, during 1990.

Airborne pollutants are subject to whatever weather conditions exist, thus wind speed and direction, rainfall, and temperature play a role in predicting how pollutants are distributed in the environment. Weather data, particularly wind speed and direction, provide references for collecting environmental samples and locating monitoring stations. For example, the FMPC added two air monitoring stations in 1986 in the predominant wind direction to evaluate concentrations of pollutants in air as distance from the site increases.

FIGURE 9: General Liquid Pathways to People



Liquid Pathway

The liquid pathway includes all releases from the FMPC that could carry waterborne pollutants (Figure 9). The effluent discharge line to the Great Miami River, the overflow spillway from the Stormwater Retention Basin, uncontrolled stormwater runoff, and groundwater all contain pollutants which could reach people through the liquid pathway. Just as with the air pathway, the first step in monitoring the liquid pathway is sampling the effluent streams as they leave the site. Types and concentrations of pollutants provide a first estimate of the potential dose that could be delivered via the liquid pathway. Some pollutants in the liquid effluent may be carried along as suspended solids which eventually settle out as sediment in the stream bed; other pollutants are dissolved in the water and could be absorbed by plants and animals. Sediment sampling in Paddy's Run and the Great Miami River provides information on whether pollutants are accumulating in the stream beds. Fish sampling can show whether pollutants are being absorbed by aquatic animals and how much radioactive material could reach people if they eat fish from the Great Miami River. Fish are known as biological integrators because they can concentrate certain pollutants as they come into contact with them. Therefore, the longer term influence of the FMPC can be measured through fish sampling.

Groundwater is an important component of the liquid pathway because it is the source of water for homes and farms in the FMPC area. Extensive sampling of the wells on the FMPC site and in the surrounding area provides information about the aquifer. By sampling the aquifer in many locations and varying depths, the FMPC can determine the extent of any contamination.

Each pathway has specific standards and guidelines which define the allowable dose limits for the pathway, and these are discussed in the next section.

Environmental Standards and Guidelines

As part of data analysis, FMPC personnel compare the data to established standards and guidelines whenever possible. These standards and guidelines have been established by numerous national and international scientific and government groups, including National Council on Radiation Protection and Measurements (NCRP), International Commission on Radiological Protection (ICRP), USEPA, OEPA, and DOE.

Organizations such as these have studied the effects of radioactive and nonradioactive materials and how they move through the many pathways in the environment to people, and from this have established standards

and guidelines to ensure that employees, people in the surrounding communities, and the environment are protected.

The DOE adopts standards recommended by the various groups of experts and publishes them in DOE orders, thereby establishing the recommendations as limits to be met by the DOE facilities. For example, DOE Order 5400.5, "Radiation Protection of the Public and the Environment," defines the guidelines for radiation exposure to the public based upon recommendations of International Commission on Radiological Protection (ICRP).[13, 14] Through reports and other guidance, the ICRP recommended a system of dose limits. Almost all countries with nuclear programs have adopted these recommendations, which provide a scientific basis for radiological protection and the selection of dose limits.

Once the DOE publishes a standard in a DOE order, such as 5400.5, each DOE site must meet the limits of radiation exposure established in that order. These limits refer to the amount of exposure a person, beyond a facility's boundary, could receive from breathing the air or drinking the water. The standards in DOE Order 5400.5 require that routine activities not cause a member of the public to receive an effective dose from all radioactive sources (except radon and its decay products) greater than 100 mrem. This dose, known as the primary dose limit, is in addition to natural background radiation (discussed in Chapter Three). Underlying all rules and requirements is the philosophy of keeping exposures As Low As Reasonably Achievable (ALARA). Therefore, the DOE expects doses from its operations to be just a small fraction of the 100 mrem per year limit.

In addition to the requirements of the primary dose limit and the philosophy of the ALARA process, DOE is subject to several pathway and source-specific limits defined in regulations developed by other federal agencies. These imposed dose limits include, but are not restricted to, doses from the air pathway and from the liquid pathway. For example, the Clean Air Act states that the air pathway (air emissions from a plant) cannot contribute more than a 10 mrem effective dose in one year to a member of the public. Again, doses from radon and its decay products are covered separately.[15] For drinking water, DOE operations cannot contribute more than 4 mrem effective dose in one year to a member of the public.[16]

DOE Order 5400.5 also establishes guidelines for concentrations of radionuclides in air emissions and in liquid effluent. These concentrations, referred to as Derived Concentration Guidelines (DCGs), are initial screening levels. The intent is that the DCGs enable site personnel to review emissions and effluent data and determine if there is a need for further investigation.

The FMPC follows these standards and guidelines in its daily operations, and must report monitoring results on a regular basis to DOE, USEPA and OEPA. Examples of these reports include:

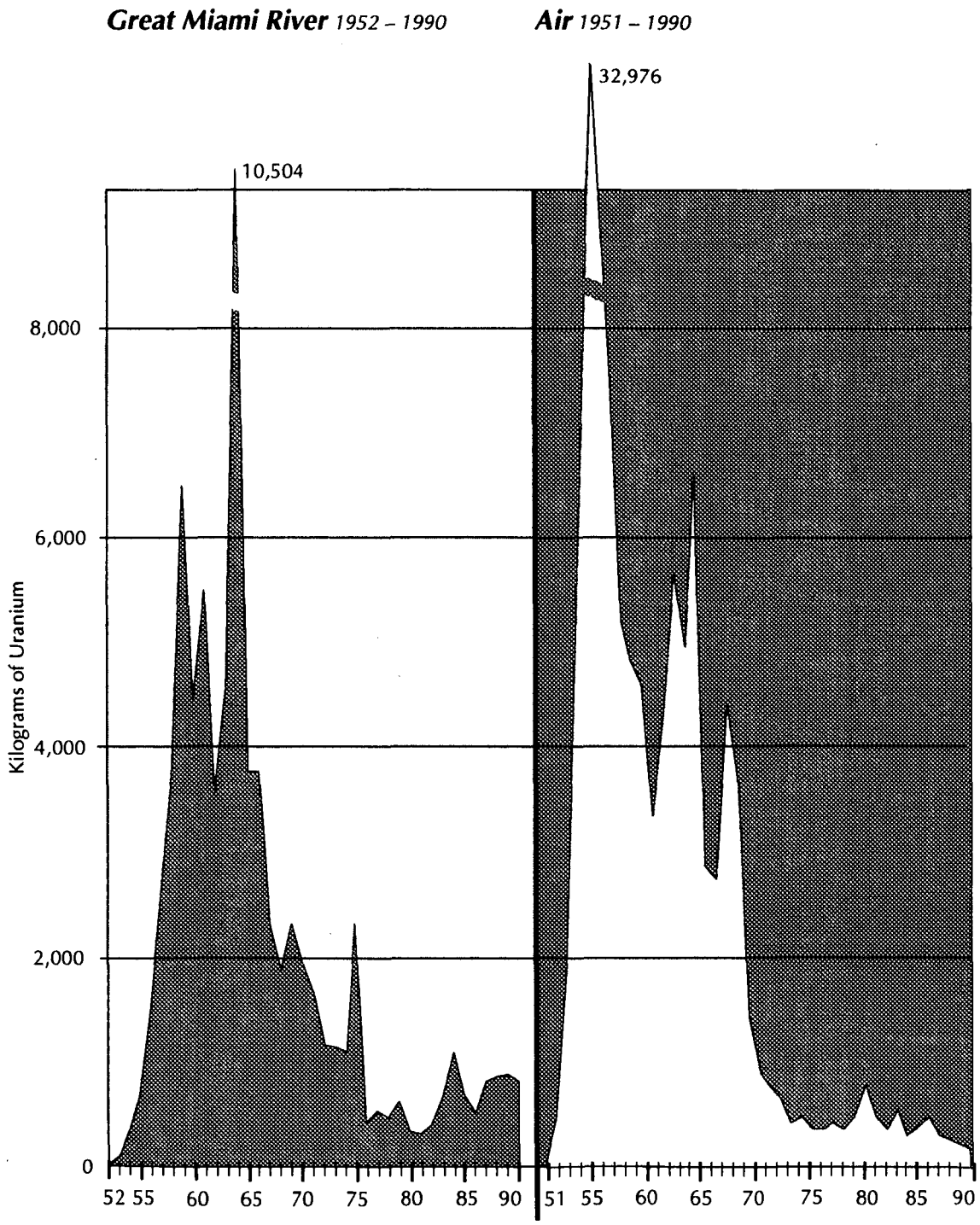
- Annual Radionuclide Air Emissions Report to DOE and USEPA,
- NPDES Monthly Discharge Monitoring Report to OEPA,
- Effluent Information System/Onsite Discharge Information System to DOE,
- Monthly Consent Agreement Report to USEPA,
- SARA 313 report to USEPA and OEPA, and
- Quarterly Report of Radionuclide Discharges to USEPA.

Throughout this report, the FMPC compares the results of its monitoring program to specific standards for various pollutants. There are some pollutants for which standards and DCGs have not yet been established. Furthermore, there are instances where standards do not exist for specific media, such as uranium in soil, grass, produce, or fish. Where no standards or guidelines are available, other points of reference are presented in order to help the reader assess the impact of FMPC operations. For example, results are compared with background data from areas unaffected by the FMPC activities. 1990 results are also compared with results of previous years to look for possible trends.

Topics Discussed in this Report

Chapter Two, Environmental Compliance Self-Assessment, contains a summary of the site's compliance status to federal and state regulations. Chapter Three, Fundamentals of Radiation, is a basic discussion of the atom, radiation, and effects of radiation on our health. Chapters Four, Five, and Six present the results of the FMPC Environmental Monitoring Program for 1990. Estimated radiation doses for 1990 are reported in Chapter Seven, which describes how the data from the sampling program are used in computer models and in calculations to estimate effects of radiation exposures to individuals and population groups near the FMPC. Chapter Eight describes quality assurance measures. The expanding waste management activities are described in Chapter Nine. Finally, Chapter Ten, Remedial Investigation and Feasibility Study, describes the CERCLA-driven comprehensive environmental study of the FMPC and surrounding area.

FIGURE 10: Yearly Record of Uranium Discharged



These graphs show the amount of uranium discharged to the Great Miami River and the air, respectively, throughout the years of FMPC operation. Total yearly data such as these eventually came to be commonplace in later Annual Environmental Reports.

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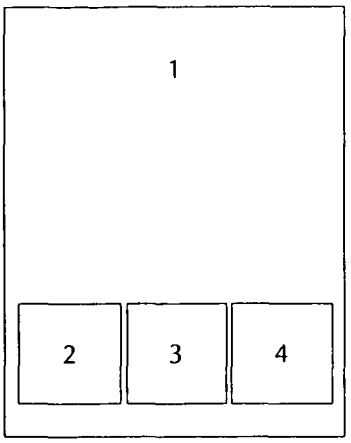
CHAPTER 2



1 – In August 1991, the site was officially renamed the Fernald Environmental Management Project, to reflect the change in mission from uranium production to environmental compliance and restoration.

2 – Results of stack sampling are used to determine compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements of the Clean Air Act.

3 – Hazardous waste is stored onsite in compliance with the Resource Conservation and Recovery Act (RCRA) until it can be shipped to a treatment or disposal facility.

4 – Water samples are taken to ensure compliance with the Clean Water Act.

CHAPTER TWO

Environmental Compliance Self-Assessment

The FMPC must comply with environmental requirements established by a number of federal and state statutes and regulations, Executive orders, DOE orders, and various regulatory compliance agreements.

These environmental requirements cover all aspects of the daily operation of the FMPC and other DOE sites. These mandatory environmental requirements are broadly defined in DOE Order 5400.1, "General Environmental Protection Program." These environmental standards fall into three categories:

- Standards imposed by federal statutes, regulations, and requirements,
- Standards imposed by state and local statutes, regulations, and requirements applicable to DOE, and
- Standards imposed by DOE directives.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at FMPC. DOE issues directives to field offices and conducts compliance audits. The United States Environmental Protection Agency (USEPA) Region V and the Ohio Environmental Protection Agency (OEPA) are the primary agencies that issue permits, review compliance reports, inspect facilities and operations, oversee compliance with applicable regulations, and participate in the CERCLA process at the FMPC.

USEPA develops, publishes, and enforces environmental protection regulations and technology-based standards as directed by statutes passed by the U.S. Congress. In some instances, USEPA has delegated regulatory authority to OEPA when the Ohio program meets or exceeds USEPA's requirements. Where regulatory authority is not delegated, USEPA Region V is responsible for reviewing and evaluating the FMPC's compliance with the USEPA regulations.

The FMPC's progress toward achieving full compliance with all environmental regulations is summarized in this chapter. It is divided into three sections — Compliance Status, Current Issues and Accomplishments, and Environmental Permits. This self-assessment covers the period from January 1, 1990 through March 31, 1991.

Compliance Status

CERCLA

In 1986, DOE and the USEPA entered into a Federal Facilities Compliance Agreement (FFCA) in which DOE agreed to comply with various federal and state pollution control regulations, including those under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The FFCA addresses the remediation of inactive waste sites, waste storage areas, and other facilities onsite.

The FMPC is on the USEPA's National Priorities List (NPL) of sites requiring environmental cleanup action under CERCLA. Consistent with the requirements of Section 120 of CERCLA pertaining to NPL lists of federal facilities, a Consent Agreement was signed by DOE and USEPA in April 1990 and became effective June 1990. This 1990 Consent Agreement replaced the CERCLA portion of the 1986 FFCA. The 1990 Consent Agreement defines five "operable units" for the FMPC site and surrounding area for the purpose of determining the extent of contamination. The operable units, which are described in the Current Accomplishments and Issues section of this chapter, and in greater detail in Chapter Ten of this report are:

- **Operable Unit 1** – Waste Pit Area,
- **Operable Unit 2** – Other Waste Units,
- **Operable Unit 3** – Production Area Activities,
- **Operable Unit 4** – Silos 1-4, and
- **Operable Unit 5** – Environmental Media.

In general, the operable units address specific areas or facilities at the site, and were defined based on their location or the potential for similar technologies to be used in the ultimate cleanup.

Consistent with the requirements of CERCLA and the Consent Agreement, the DOE is conducting a Remedial Investigation/Feasibility Study at the FMPC. Through the implementation of this study, the DOE will thoroughly investigate existing and potential environmental impacts associated with facility operations and systematically select final remedial action alternatives to address identified environmental concerns. Separate reports and decision documents that summarize the results of the RI/FS process are being prepared for each operable unit.

RCRA

The FMPC generates both hazardous wastes and mixed wastes (containing hazardous and radioactive wastes). Hazardous wastes accumulate at locations throughout the facility known as satellite accumulation areas. The wastes are then stored in designated RCRA storage facilities until they can be shipped offsite to a RCRA-permitted treatment or disposal facility. Because facilities that can treat or dispose of mixed waste are limited in number and capacity, most of the RCRA waste stored onsite is mixed waste.

On April 5, 1990, the State of Ohio filed contempt of court charges against the FMPC. Negotiations resulted in a Proposed Amended Consent Decree (PACD). The PACD outlines many requirements, including hazardous waste characterizations, a Drum Management Plan, closure plans for Underground Storage Tank 5 and Waste Pit 5, a timetable for submitting the revised Part A and Part B permit application, and a report of all known hazardous waste management units. Hazardous waste characterizations are being completed as scheduled. A required quarterly report on the PACD process will include a revised waste analysis plan and will be submitted during 1991. The first quarterly report was filed in January 1991.

The PACD requires that the FMPC identify all Hazardous Waste Management Units at the site. As a result, the FMPC is investigating burners, incinerators, furnaces, stills, process equipment, tank units, and dust collectors to determine if they are Hazardous or Solid Waste Management Units.

Other RCRA actions include conducting quarterly surveillances to verify adherence of site activities to regulatory and quality site procedures. The Deviation Corrective Action Report is used to track the site's progress in improving procedures.

The RCRA Annual Report was sent to the OEPA by March 1, 1991. This report included the following:

- Facility Hazardous Waste Report,
- Generator Hazardous Waste Report,
- Waste Minimization Report, and
- Groundwater Monitoring Annual Report.

Material Evaluation Forms have been implemented as a systematic and consistent method to characterize waste. These forms include information on waste generation, process knowledge determinations, proper labeling, and storage requirements.

Clean Air Act

In Ohio, authority to enforce requirements of the Clean Air Act has been delegated by the USEPA to the OEPA, except for the enforcement of the National Emission Standards for Hazardous Air Pollutants (NESHAP). Because most of the FMPC's air emission sources potentially emit both radioactive and nonradioactive particulates, operation of most FMPC sources requires the approval of both regulating agencies.

In February 1990, the FMPC was found in violation of 40 CFR 61.07 for 14 sources of radionuclide air emissions. Specifically, the FOV stated that applications for approval to modify the 14 sources had not been submitted in a timely manner as required in the regulations. The FMPC has since resolved the FOV for all 14 sources by either submitting and obtaining USEPA approval of an application for approval to modify, or by rendering the source inoperable.

The FMPC estimated airborne uranium emissions for 1990 were 3.2 kg (7.2 pounds). Since production has ended, FFCA stack testing has been postponed, but will be scheduled if any facilities required for waste management and cleanup activities are restarted.

Clean Water Act

As part of the Clean Water Act, the FMPC is governed by a National Pollutant Discharge Elimination System (NPDES) permit issued by the State of Ohio and must control the discharge of nonradiological pollutants to Ohio waters. The permit, which was renewed on February 12, 1990, specifies discharge and sampling locations, sampling and report schedules, discharge limitations, water quality standards, and other discharge restrictions. The current permit specifies eight regulated monitoring locations; two locations are for discharges directly to Ohio waters and six are internal contributing effluent streams.

Liquid effluent samples collected at the NPDES locations during 1990 indicated that the FMPC met the NPDES daily maximum and monthly average permit limits more than 99% of the time. The total of 50 exceedances for the year is significantly higher than for 1989. It should be recognized, however, that due to the increased requirements of the new permit, the total number of analyses during 1990 more than tripled compared with 1989. Of 5,137 analyses, 5,087 were within the limits of the permit.

The 50 exceedances occurred primarily for two constituents: fluoride and pH. Ten of the 11 fluoride exceedances occurred at an internal monitoring point located at the effluent from the biodenitrification system.

Fluoride concentrations at the discharge to the Great Miami River were not above permit requirements.

Of the 28 pH exceedances that occurred during 1990, 20 were at the discharge to the Great Miami River; the remaining eight occurred at internal monitoring points. The primary cause of these exceedances is believed to be problems with implementing the continuous monitoring for pH required by the renewed NPDES permit. After installation of the continuous pH monitors, problems were experienced in keeping the instruments calibrated. The instruments periodically drifted out of calibration causing a reading above the upper permit limit of 9.0. In most cases, grab samples taken at the same time indicated that the actual pH was within the permit limits. Because the continuous monitoring of pH is a requirement of the new permit, the readings were reported to OEPA as exceedances.

During 1990, the FMPC discharged 786 kg (1,733 pounds) of uranium into the Great Miami River through its regulated discharge at Outfall 001.

Toxic Substances Control Act

The FMPC stores radioactively contaminated PCB materials from past operations and maintenance activities. These materials are stored in Building 79 in compliance with TSCA requirements. The Notification of Activities form required by revised TSCA regulations was submitted in April 1990, and USEPA has responded by issuing a facility identification number. A document log and annual PCB report is completed by July 1 of each year and maintained in files at the FMPC. The FMPC is exploring various disposal options for mixed PCB items and articles in storage.

Infectious Waste

The 1988 Ohio Solid Waste Act and its subsequent revisions regulate infectious waste. The FMPC is considered a small generator under Ohio law because the medical department generates less than 23 kg (50 pounds) of infectious waste — such as hypodermic needles — per month. Therefore, generator registration with the state is not required. However, surveillances are performed to ensure the waste is properly managed. All wastes are shipped offsite on a regular basis for incineration.

Current Accomplishments and Issues

This section presents compliance-related accomplishments for 1990 through March 1991, and looks at ongoing compliance issues at the FMPC.

CERCLA/SARA

Notices of Violation

The original Federal Facility Compliance Agreement between DOE and the USEPA was signed in 1986, and the cleanup portion of the FFCA was updated in 1990. In 1990, the USEPA issued four Notices of Violation and assessed stipulated penalties against DOE for alleged violations of the Compliance Agreement. The NOVs were in regard to the following actions:

- Inadequate initial screening of alternatives for Operable Unit 3,
- Incomplete remedial investigation documents for Operable Unit 4, and
- Two notices for incomplete access agreements for Operable Unit 5.

The DOE disputed the stipulated penalties for the NOVs and DOE elevated the dispute to the USEPA Administrator on March 22, 1991.

On May 13, 1991, the UPEPA and DOE jointly signed an agreement resolving these disputes and NOVs. One component of this agreement was recognition of the need for involved parties to enter into negotiations on the scheduled milestones contained within the 1990 Consent Agreement. These negotiations were initiated in May 1991 and were ultimately concluded with the issuance of an Amended Consent Agreement in September 1991. The Amended Consent Agreement established new schedules for the completion of the ongoing Remedial Investigation/Feasibility Study and provided commitment for the completion of a series of new removal actions at the facility.

Removal Actions

In the course of a RI/FS effort, conditions are occasionally identified which call for immediate action in order to address releases or potential releases of hazardous substances. These actions, called removal actions, are coordinated with USEPA and OEPA.

The primary removal actions being conducted during 1990 under CERCLA at the FMPC are:

- Contaminated water beneath FMPC buildings,
- Waste pit area runoff control,
- South groundwater contamination plume,

- Silos 1 and 2,
- K-65 decant sump tank,
- Waste Pit 6 residues, and
- Plant 1 Pad continuing release.

The following paragraphs provide a status of the removal actions as of March 25, 1991.

Contaminated Water Beneath FMPC Buildings

This removal action is designed to minimize the potential for uranium-contaminated perched groundwater located underneath process buildings to infiltrate the Great Miami Aquifer. Initial pumping operations in Plant 6 began in late 1989. VOC contamination in the discharge was identified in the spring of 1990. Pumping is on hold as of March 25, 1991, pending design and installation of a VOC treatment system in Plant 8 for all perched water. The removal action will then continue for perched groundwater under Plant 6 and later Plants 2/3, 8, and 9.

Waste Pit Area Runoff Control

The objective of this removal action is to collect and treat contaminated stormwater runoff from the waste pit area currently flowing to Paddy's Run. The removal action work plan and, specifically, the sampling and analysis plan, have been modified to include pre-excavation soil sampling for hazardous substance listed contaminants as requested by USEPA and OEPA. The USEPA conditionally approved the revised work plan on January 10, 1991, with modifications pertaining to sampling requirements. The OEPA reviewed the modified sampling and analysis plan and issued conditional approval based on the satisfactory resolution of questions concerning pre-excavation soil sampling.

South Groundwater Contamination Plume

The purpose of this removal action is to protect health by managing radioactively contaminated groundwater in private property south of the FMPC. Access to and use of the groundwater with excessive uranium contaminations is limited.

Part 1 of the removal action includes providing an alternate source of water to two industries affected by the contaminated plume. As of March 25, 1991, review of the drawings and specifications for Part 1 was 90% completed. Testing of the selected well field will begin after easements for private property are obtained.

Part 2 of the removal action consists of the installation of an extraction well system. Groundwater from the South Plume will be pumped back to the FMPC, monitored, and then discharged to the Great Miami River via

Manhole-175. The project has been split into two construction packages. The first package, which is the more time-consuming to construct, contains the transfer pump station, groundwater discharge pipeline, and the outfall pipeline. The second package contains the well field details, and construction will be delayed until the location of the well field is agreed upon by FMPC and OEPA.

Part 3 of the removal action is the design and installation of an Interim Advanced Wastewater Treatment system to remove uranium from existing plant waste water streams. The goal is to reduce contaminant loading to the Great Miami River to less than 773 kg (1,700 pounds) per year, which is less than the 1989 discharge level. This includes the additional contaminated flows from the projected removal actions (Waste Pit Area Runoff Control, the South Groundwater Contamination Plume, and Contaminated Water Beneath FMPC Buildings). The Design Basis Document has recently been approved. Construction for parts 2 & 3 is estimated to begin in mid-1992.

Part 4 of the removal action involves future groundwater monitoring and institutional controls. This activity will be implemented by continuing the existing groundwater monitoring program.

Silos 1 and 2

The scope of this removal action can be broadly defined as reducing the radon emissions from silos 1 and 2 (the K-65 Silos), and providing minimal control of the potential releases of residues from these silos. The selected alternative for the removal action, documented in the Engineering Evaluation and Cost Estimate, underwent public comment in the fall of 1990. It involves placing bentonite slurry into the two silos.

Design efforts necessary to implement this removal action began after the USEPA approved the silos 1 and 2 removal action work plan. Implementation of this removal action is expected to begin in September 1991, with the bentonite slurry in place by December 1991.

K-65 Decant Sump Tank

This removal action is designed to remove and further define disposition of water in the decant sump tank located between silos 1 and 2. The tank was used to store liquid that was drained from the K-65 Silos after solids had settled. Removal of this water from the underground sump tank will mitigate the potential for a release to the environment. USEPA approved with comments the work plan for this removal action on January 10, 1991. Pumping and removing of the decant liquid began in late March 1991. The liquid will be stored in the Plant 2/3 holding tanks until the analytical results are available and a RCRA determination has been made.

Waste Pit 6 Residues

The purpose of this removal action was to eliminate a potential airborne contamination problem. Pit 6 contains primarily uranium residues and asbestos. Most of the surface area of the 3,010 m^2 pit was covered by water; however, 446 m^2 were exposed and the dry material could have contributed to airborne emissions. These factors made a removal action appropriate due to potential offsite exposure.

The FMPC considered several alternatives, including:

- Taking no action,
- Covering,
- Removing and placing of exposed material in containers,
- Distributing material below water level,
- Spraying on sealant, and
- Maintaining higher water level.

The evaluation of alternatives determined that distributing exposed material below the existing water level of the waste pit was the preferred method for accomplishing the goals of the removal action.

To prevent the spread of contamination during the removal action, the dry material was moved by crane and clamshell, a light water spray was used to control dust, and a three-zone contamination barrier was established. This removal action was completed in December 1990.

Plant 1 Pad Continuing Release

The purpose of this removal action is to mitigate uncontrolled releases from the pad near Plant 1 in order to protect the underlying soil and water. Steps are underway to accomplish the following:

- Prevent runoff from the pad,
- Provide covered, controlled storage for portions of the pad,
- Place new concrete over the existing pad, and
- Use polyethylene liners and epoxy coatings to protect the environment.

The work plan for this removal action was submitted to USEPA and OEPA on December 4, 1990. Construction on this removal action should begin in 1991.

An additional action during this reporting period included the forming of the CERCLA Integration group to integrate all site activities with CERCLA. This group reviews documentation such as remedial investigation reports, feasibility studies, removal site evaluations, and removal actions. It has also prepared tables of Applicable or Relevant and Appropriate Requirements (ARAR) for removal actions.

SARA, Title III

To comply with SARA Title III reporting requirements, a system was implemented to track and report, as necessary, weight discrepancies discovered during overpacking operations. During 1990 and January 1991, the FMPC reported four weight discrepancies as potential releases. Each report involved a SARA release report to the State Emergency Response Commission and reports to the Local Emergency Planning Committee. In addition, 14 releases — not including weight discrepancies — exceeded the reportable quantity and involved notification to the National Response Center, OEPA, and USEPA.

The SARA 312 report was also completed and submitted by the March 1, 1991 deadline. This report lists the amount and location of hazardous substances which meet the minimum reporting threshold amounts.

RCRA

RCRA Closures

During this reporting period, the FMPC took the actions described in the following paragraphs as part of the following RCRA closures:

- Trane incinerator,
- Tanks T-5 and T-6,
- Storage pad north of Plant 6, and
- Underground storage tank 5.

The OEPA approved the FMPC Trane Incinerator Closure Plan. Since then, ancillary equipment to the Trane Incinerator has been identified. On July 13, 1990, the FMPC submitted a sampling plan and an amended closure plan to include the ancillary equipment and to request an extension to the closure period.

For tanks T-5 and T-6, a revised closure plan was submitted to the OEPA in January 1991. The closure plan was revised to incorporate OEPA's review comments. The revised plan is currently under review by the OEPA.

A revised closure plan for storage pad north of Plant 6 was submitted to OEPA in December 1990. The plan was revised to address when RCRA action levels or remediation under CERCLA will be implemented.

A closure plan for Underground Storage Tank 5 was submitted to the OEPA in October 1990 pursuant to the PACD.

RCRA Determinations

Pursuant to the PACD, a characterization program is to be completed by October 1992. The characterization program encompasses both process knowledge and sampling and analyses requirements. The characterization includes:

- Completed process knowledge determinations for 1,800 drums of suspect materials in RCRA storage,
- Completed initial process knowledge determinations for the 8,000 drums of material not affected by the Hazardous Waste or Solid Waste Management Unit review,
- Completed initial process knowledge determinations for the 8,000 drums of material affected by the HWMU/SWMU review, and
- A Waste Determination Plan, approved by OEPA, which identifies the approach the site will take in conducting the characterization program.

NEPA

The NEPA/CERCLA integration strategy for incorporating NEPA requirements into the site remediation program was developed and implemented during 1990. The strategy calls for integrating the EIS/EA level information into the FS documents. Two public scoping meetings for the remediation EIS/EA were held in late June 1990.

The FMPC developed and implemented training programs to assure that personnel responsible for planning and conducting the FMPC activities are aware of the requirements for compliance with NEPA.

NEPA documents were prepared to analyze the environmental impact of CERCLA removal actions. A strategy was developed for assuring that NEPA requirements are fulfilled for the remedial actions identified by the RI/FS process.

Land Disposal Restricted Waste

The FMPC currently stores mixed waste subject to the Land Disposal Restrictions. This mixed LDR waste is being stored only because of the lack of treatment and disposal facilities for this type of waste. On April 12, 1990, the FMPC did ship some nonradioactive LDR waste offsite for disposal — 20 kg (44 pounds) of lab-pack chemicals and 45.3 kg (100 pounds) of spent acetonitrile.

Clean Air Act

New, more stringent NESHAP rules under Subpart Q became effective in March 1990, establishing standards for radon emissions from federal facilities. The FMPC has three above-grade silos which emit radon and are affected by these standards. The CERCLA removal and remedial actions being developed for these silos, as part of the CERCLA work at the FMPC, include measures addressing the emission of radon from the silos.

Permits to Install (PTI) were approved by the Southwest Ohio Air Pollution Control Agency (SWOAPCA) and the OEPA for the new Decommissioning & Decontamination Facility and the Plant 1 Large Drum Sampling Station on December 5, 1990.

A review of the permits being processed by SWOAPCA concluded that about 10% of the permits were no longer required due to the end of production. In addition, documentation was transmitted to the OEPA to allow operation of a temporary boiler to provide steam during emergency repair procedures of one of the two FMPC boilers.

The Permits to Operate (PTO) for the FMPC Boiler Plant allow 12% maximum ash content for coal. The contract for purchasing coal in 1991 was amended to 8% maximum ash content, with the vendor to supply analysis prior to the delivery of the coal. This change was implemented to assure that the permit limit will not be exceeded.

Radon Sources

On December 15, 1989 USEPA issued NESHAP Subpart Q regulations governing emissions of radon from storage or disposal facilities at DOE sites. These regulations specify a maximum flux (emission rate per unit volume) of radon that can be emitted from each facility. To respond to these new regulations, FMPC agreed with USEPA that compliance with the radon flux standard for sources such as the K-65 Silos should be achieved to the extent possible by implementing the removal actions and final remedial actions identified through the CERCLA RI/FS process. FMPC also committed to providing USEPA with estimates of the radon flux from potential radon sources at the site, as part of the RI/FS. These committed responses toward compliance were formally included in a Federal Facility Agreement (FFA) for Control and Abatement of Radon–222 Emissions dated November 19, 1991.

Questions concerning methods for radon flux measurement from the FMPC waste pits and K-65 Silo berm were resolved with the USEPA. Estimates of the radon flux from Silo 3 and Waste pits 1, 2, and 3 were transmitted to USEPA Region V on December 17, 1990. The estimates

will provide a basis for comparison with the NESHAP Subpart Q flux standard, and will be included in the RI being conducted of these areas.

Asbestos

An assessment of the revised NESHAP regulations for asbestos was completed during December 1990. Implementation of the new requirements for the FMPC asbestos removal and demolition activities was begun. In addition, asbestos removal notifications were prepared for direct submission to Southwestern Ohio Air Pollution Control Agency. In October 1990, an Asbestos Council was formed to assure adequate coordination and management of asbestos activities.

Stack Samplers

Calibration and maintenance of stack samplers procedures were revised. Current actions are designed to ensure that dust collectors do not operate and that equipment cannot be restarted without adequate monitoring in place.

Clean Water Act

Offsite Water Supply Wells

Prior to 1990, the FMPC had identified three offsite water-supply wells contaminated with uranium. The first landowner was provided with a new deep well as an alternate drinking water source. An Engineering Evaluation/Cost Analyses for CERCLA removal actions to supply alternate water sources was performed for the other two locations. The EE/CA was approved by USEPA and OEPA and is in the design stage. The uranium concentrations in these three wells ranged from 38 to 330 parts per billion for this reporting period.

During 1990 and the first quarter of 1991, the FMPC identified above-background uranium concentrations in three other offsite water-supply wells south of the site. The total uranium concentrations in these wells ranged from 3.4 to 8.1 ppb. Even though these levels are well below DOE guidelines, they are above the upper range of background uranium concentrations for this area, so the FMPC decided to supply bottled drinking water to these three landowners. The FMPC continues to monitor groundwater sources closely as part of its systematic groundwater program.

Groundwater Monitoring Wells

During the 1980s, about 170 monitoring wells were installed in and around the FMPC site to identify and track the movement of contaminants which may be present in the groundwater. The highest historical concentration of uranium in an onsite sand and gravel aquifer well was

measured during 1990 at a concentration of 907 ppb. The highest concentration of uranium in an offsite sand and gravel aquifer monitoring well during 1990 was 312 ppb.

A program for handling purge water from quarterly RCRA groundwater monitoring activities was submitted to the OEPA on December 24, 1990. The program outlined procedures to be taken if concentrations of RCRA hazardous constituents are detected in wells. Purge water potentially exceeding Toxicity Characteristic Leaching Procedure standards is to be analyzed using this test before determining its disposition. Nonhazardous purge water is discharged to the General Sump if its discharge does not exceed the NPDES notification levels.

Toxic Substances Control Act

Thirty-five drums of nonradioactive PCBs and nonradioactive PCB items were shipped to a commercial facility for incineration and disposal in October 1990. Another shipment of PCB items is scheduled. After the scheduled shipment, the only remaining PCBs onsite will be those which have been determined to be radiologically mixed. Because there are no viable disposal solutions for radiologically mixed PCBs, other options are being explored, such as decontamination or possible shipment to the Oak Ridge facility for incineration in the TSCA incinerator.

Federal Insecticide, Fungicide, and Rodenticide Act

A site inventory and reconciliation pursuant to FIFRA was performed, and a site document was prepared identifying all areas on site that have had pesticides applied. This document was prepared to address construction rubble determinations.

Environmental Permits

The FMPC must obtain and operate by a number of environmental permits to be in compliance with current environmental statutes. A summary of the environmental permits required and issues surrounding these permits follows.

Air Permit Applications

Under the federal Clean Air Act and Ohio law, the FMPC must obtain permits to install and operate equipment that is a source of emissions to the atmosphere. During 1990, the FMPC submitted three PTI and 13 PTO applications to OEPA for their review and approval. The FMPC received five PTIs and 46 PTOs during 1990.

Under NESHAP regulations in effect before the December 15, 1989 changes, the DOE submitted Requests for Determination of Modification on six ongoing projects. With the end of production at the FMPC, four of the projects were found to involve equipment or processes which would never be operated. Based on this determination, no Requests for Approval were filed with the USEPA. Applications were filed for the remaining two projects. One was approved in 1990, the other received approval in early 1991.

Water Permit Applications

During 1989, the FMPC resubmitted the PTI application for the Coal Pile Runoff control project to OEPA. In addition, the FMPC submitted permit information to USEPA and OEPA for the Waste Pit Area Runoff Control Project. Since this project is a CERCLA Removal Action, permit documentation is required for informational purposes rather than as a PTI application.

National Pollutant Discharge Elimination System

The NPDES permitting process for the FMPC is under the jurisdiction of the State of Ohio to control the discharge of nonradioactive pollutants to Ohio waters. The permit specifies sampling locations, sampling and reporting schedules, discharge limits, water quality standards, and other restrictions on FMPC effluent to the Great Miami River and Paddy's Run. The FMPC met the NPDES daily maximum and monthly average permit limits more than 99% of the time during 1990.

January and February 1990 were the last two months that the FMPC operated under the previous NPDES permit. That permit specified seven monitoring locations — two were discharges directly to Ohio waters (Outfalls 001 and 002) and five were internal contributing effluent streams.

Ohio EPA issued the FMPC's new NPDES Permit on February 12, 1990, and the revised monitoring requirements took effect in March 1990. The new permit significantly increased monitoring requirements compared to the previous permit. For example, the new permit added the following:

- Continuous monitoring and discharge limits for pH at several outfalls,
- Discharge limits for several new constituents, such as fluoride and various metals, and
- A requirement for monitoring the discharge of stormwater collected in the Stormwater Retention Basin.

RCRA Permits

In accordance with the new Toxicity Characteristic rule, the Part A Permit Application (Revision 10) was submitted to the USEPA and the OEPA in September 1990. The revisions included new TC waste codes or combinations promulgated by the TC rule. In addition, the revised Part A Application included the Plant 1 Pad as a unit the FMPC is seeking to permit.

As a result of the PACD characterization program, the FMPC Waste Analysis Plan (Section C of the Part B Permit Application) was revised and submitted to the OEPA on January 15, 1991. The revised WAP included RCRA waste streams identified as a result of the continuing waste determination activities at the site.

Under the PACD, the FMPC is to revise the Part A Permit by June 30, 1991, and the Part B Permit by October 31, 1991.

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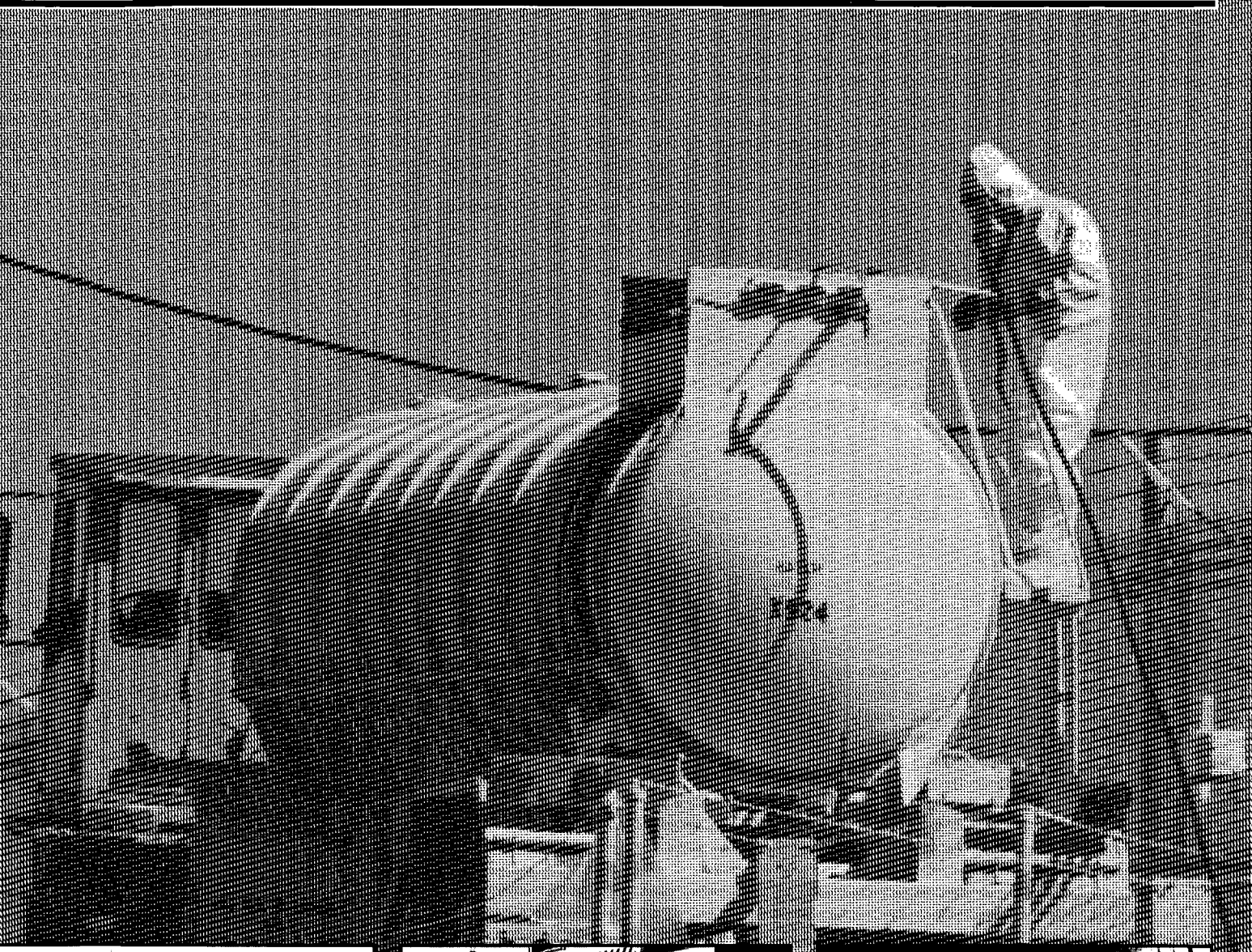
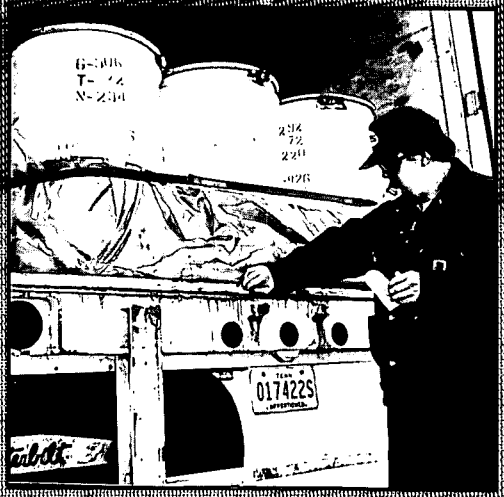
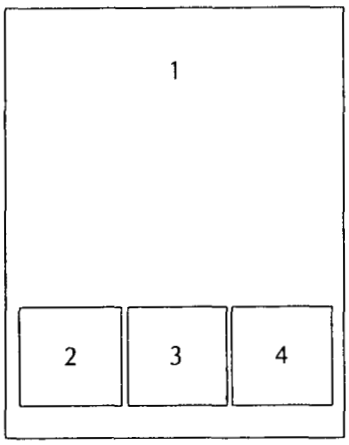
CHAPTER 3







1 – Workers take care to wear protective clothing when working with and around radioactive materials.

2 – Radiation meters, sensitive to ionizing particles and rays, are used to monitor for radioactive contamination.

3 – Contaminated materials are disposed of in designated containers which are sealed and labeled.

4 – A smear sample may show if equipment that has been in contact with radioactive materials has become contaminated.

CHAPTER THREE

Fundamentals of Radiation

Since the FMPC works with radioactive materials, terms unique to radiation and its potential health effects are used extensively throughout this report. As a result, some of the important information in the report may be difficult for the nonscientist to interpret. This chapter provides a way to put that information into perspective, and includes the following topics:

- The atom,
- Radioactivity and radiation,
- The units used to measure radiation,
- Background radiation, and
- The effects of radiation.

If you are familiar with the concepts and terms used in the study of radiation, you may wish to proceed directly to the next chapter on the Air Pathway Monitoring Results.

The Atom

The world is made up of atoms. Atoms consist of two basic parts:

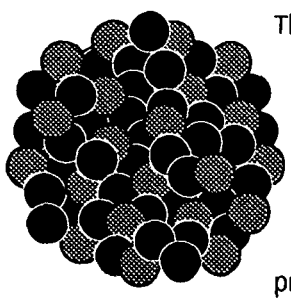
- The nucleus and
- The electrons orbiting the nucleus.

The nucleus is made up of protons, which are positively charged, and neutrons, which have no charge. Protons and neutrons are similar in size, and both of them are considerably larger than electrons (about 1,800 times more massive). Therefore, the weight and mass of the atom is principally concentrated in the nucleus. The electrons circling the nucleus have a negative charge. To keep the atom electrically neutral, the number of electrons in an atom must equal the number of protons. (See Figure 11 below.)

Protons and electrons have many characteristics similar to magnets. Just as opposite magnetic poles are drawn toward each other, protons and electrons are attracted toward each other. This attraction keeps the electrons orbiting around the nucleus. The electrons are not pulled into the nucleus because of the electrons' energy. This energy keeps them constantly moving and away from the protons. The energy in the electrons and the attraction of the electrons to the protons balance each other and keep the electrons in orbit. Just as there is energy in the electrons to keep them orbiting, there is energy in the nucleus to keep the protons and neutrons together.

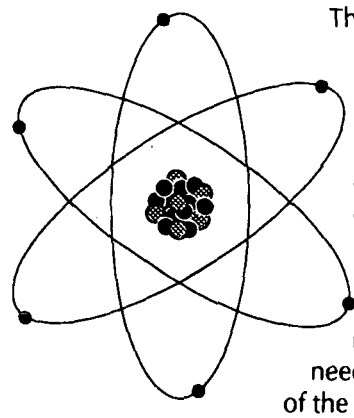
FIGURE 11: Structure of the Atom

The Nucleus of an Atom



The nucleus has many protons (green) and neutrons (black). Notice that there are never two protons touching each other. Similar to a magnet, the positively charged protons repel each other. There must be neutrons separating the protons.

Electrons Orbiting the Nucleus



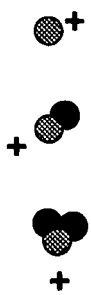
The electrons, like the protons, repel each other. Only two electrons can be on a path around the nucleus, and the two are always at opposite ends of the path. There will be as many paths as needed to hold all of the electrons.

The number of protons in the nucleus is referred to as the atomic number. The atomic number is the identifier of the atom. If it changes, the number of electrons and the chemical properties of the atom change. For example, for an atom to be hydrogen, it must have one proton. If a hydrogen atom were to gain a proton, it would no longer be hydrogen; it would be helium, which has two protons. Uranium has 92 protons. Since protons are positively charged, the atom must also have 92 electrons for it to be electrically neutral.

The sum of the protons and neutrons in the nucleus is called the mass number. Unlike protons, the number of neutrons a specific atom contains can vary since they have no charge and don't need to be balanced by electrons. Therefore the mass number can vary. For example, a hydrogen atom always has one proton, but it can have either zero, one, or two neutrons. The different hydrogen atoms are called isotopes of hydrogen. Isotopes are labelled with their mass number. A hydrogen atom without a neutron is referred to as hydrogen-1 where 1 is the mass number. The hydrogen isotope with one neutron is referred to as hydrogen-2, and the isotope with two neutrons is referred to as hydrogen-3.

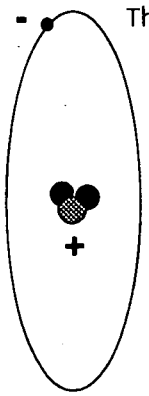
Most of the uranium at the FMPC contains 146 neutrons to go with the 92 protons present in every uranium nucleus; therefore, the mass number is 238 (146 neutrons + 92 protons = 238). Uranium-234 has 142 neutrons + 92 protons, uranium-235 has 143 neutrons + 92 protons, and uranium-236 has 144 neutrons + 92 protons. All isotopes of uranium are radioactive. Radioactivity and radiation are described in the next section.

The Hydrogen Nucleus



The hydrogen nucleus always has one proton and can have zero, one or two neutrons. The protons are positive and the neutrons are neutral.

The Hydrogen Atom



The hydrogen atom consists of the nucleus and the electron orbiting the nucleus. Since the hydrogen atom has one proton, it must have one electron to be electrically neutral.

Radioactivity and Radiation

Radioactivity is a process in which a nucleus of an unstable atom spontaneously decays or disintegrates. Radiation is the energy that is released as particles or waves when the disintegration or decay of the nucleus occurs. This section includes a discussion of radioactive decay and the three main forms of radiation produced by radioactivity:

- Alpha particles,
- Beta particles, and
- Gamma rays.

Radioactive Decay

Atoms are radioactive because their nucleus is too large (because of the number of protons and neutrons) or has too much energy to remain stable. By emitting radiation, the nucleus releases energy and moves toward a more stable, less energetic state and eventually becomes a stable atom. Radioactive decay occurs everywhere on earth because of naturally occurring radioactive elements. When most radioactive elements decay, the resulting atom is also radioactive. This is called a radioactive decay chain. There are four natural radioactive decay chains. A common chain begins with uranium-238 and ends with lead-206 (this isotope of lead is stable, which means it does not decay). Each of the various radioactive atoms (radionuclides) created during the decay sequence has its own natural rate of decay.

The uranium decay sequence is an example common in nature and here at the FMPC. (The uranium and thorium decay chains are presented on the following page.) Uranium-238 emits an alpha particle (two protons and two neutrons) and becomes thorium-234. Then a neutron in thorium-234 becomes a proton and an electron. The electron is emitted as a beta particle. Then thorium-234 decays to protactinium-234. The decay process proceeds in this manner. Much of the uranium and thorium at the FMPC has been chemically purified and separated from other elements shown in the decay series. Elements separated from uranium and thorium are some of the wastes stored at the FMPC. The material stored in the K-65 Silos is an example of such waste.

It takes a different amount of time for each element to decay to the next element in the chain. The amount of time it takes for a radioactive substance to lose half of its radioactivity, or for half to become the next element in the chain, is its half-life. All decay chains found in nature begin with an isotope with an extremely long half-life. It is assumed that these atoms were formed at the same time as all the other atoms on earth and are still present because their half-lives are comparable to the age of the earth.

Nuclides of the Uranium Decay Chain

Isotope	Half-life	Radiation
Uranium-238	4,500,000,000 years	alpha
Thorium-234	24 days	beta, gamma
Protactinium-234m	1.2 minutes	beta, gamma
Uranium-234	250,000 years	alpha, gamma
Thorium-230	80,000 years	alpha, gamma
Radium-226	1,622 years	alpha, gamma
Radon-222	3.8 days	alpha
Polonium-218	3.05 minutes	alpha
Lead-214	26.8 minutes	beta, gamma
Astatine-218	2.0 sec	alpha
Bismuth-214	19.7 minutes	beta, gamma
Polonium-214	0.000164 seconds	alpha, gamma
Thallium-210	1.3 minutes	beta, gamma
Lead-210	22 years	beta, gamma
Bismuth-210	5.0 days	beta
Polonium-210	138 days	alpha, gamma
Thallium-206	4.2 minutes	beta
Lead-206	Stable	none

Nuclides of the Thorium Decay Chain

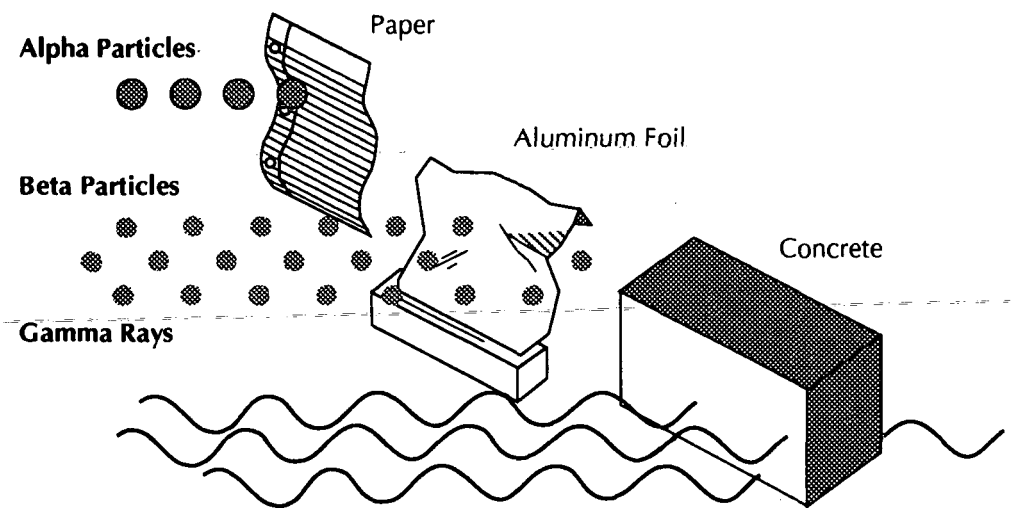
Isotope	Half-life	Radiation
Thorium-232	14,000,000,000 years	alpha
Radium-228	6.7 years	beta
Actinium-228	6.13 hours	beta, gamma
Thorium-228	1.9 years	alpha, gamma
Radium-224	3.64 days	alpha, gamma
Radon-220	55 seconds	alpha
Polonium-216	0.16 seconds	alpha
Lead-212	10.6 hours	beta, gamma
Bismuth-212	60.5 minutes	alpha, beta, gamma
Polonium-212	0.000000304 seconds	alpha
Thallium-208	3.1 minutes	beta, gamma
Lead-208	Stable	none

Example To illustrate the idea of half-life, let's look at the isotope thorium-234. Its half-life is 24 days. If you started with 1,000 atoms of thorium-234, after 24 days you would have 500. After another 24 days you would have 250, and so on. The half-life of some isotopes, such as uranium-238, is very long. The middle column in the uranium and thorium decay chain examples contains the half-life periods of the elements in the decay chain. All the radionuclides in the Uranium Chain can be thought of as "potential" lead-206 atoms. This will be the case many billions of years into the future when all natural radioactive isotopes will have decayed to their stable end products.

Alpha Particles

Alpha particles consist of two protons and two neutrons and have a positive charge. Because they are charged, they interact with other atoms by scattering off other charged particles, thus losing their energy. Moreover, because of their large size, alpha particles do not travel very far when emitted (one to eight centimeters in air). They are unable to penetrate any solid material, such as paper or skin, to any significant depth (Figure 12). However, if alpha particles are released inside the body, they can damage the soft internal tissues because they deposit all their energy in a very small volume. Uranium decays by emitting alpha particles, so if uranium particles are inhaled or swallowed, the emitted alpha particles may damage internal tissue. Other radionuclides present at the FMPC that decay by emitting alpha particles include thorium-228, -230, and -232.

FIGURE 12: Types of Ionizing Radiation



Beta Particles

Beta particles are electrons and carry a negative electrical charge. They are much smaller than alpha particles and travel at nearly the speed of light, thus they can travel for longer distances in air and penetrate solid materials more readily than alpha particles. Beta particles interact with other atoms in ways similar to alpha particles, but since they are smaller, faster, and have less charge, they cause less concentrated damage when interacting with tissue. Thorium-234, a decay product of uranium-238, emits beta particles.

Addressing Homeowner Concerns about Uses of Well Water

Several homeowners near the FMPC have expressed concern as to why well water with low concentrations of natural uranium may be acceptable for household utility uses such as washing clothes, bathing, and watering plants, but may not be acceptable for drinking or cooking. To some, this has seemed an inconsistency and cause for misunderstanding.

The key to understanding why the water is acceptable for external uses is an understanding of how alpha particles, of prime concern when dealing with uranium, deliver a radiation dose. Alpha particles are large, charged particles that readily interact with other materials. This interaction prevents the particles from ever penetrating very deeply. Even the most energetic alphas from uranium are stopped by the outer layers of dead skin.

However, inside the body, there are no protective dead cell layers to prevent the alpha particles from interacting with live organ cells; all emitted energy is delivered as dose to the organ. The alpha-emitting radionuclide may also be incorporated into the cell structure as if it were a different chemical. For example, the body processes several radionuclides as though they were calcium; predictably, they end up being deposited in the bones. Research has shown that uranium tends to concentrate in the bone and, to a lesser extent, in the liver, kidneys, and other tissues.

There is also a chemical toxicity associated with uranium, independent of its associated radiation hazards. Studies indicate that uranium is toxic to the kidney cells in high intensive doses (30,000 pCi/L) or lower persistent doses (3,000 pCi/L).

Although the concentrations of concern in these studies are several thousand times greater than the concentration of uranium in local groundwater, it may be desirable to limit the intake of uranium. While no measurable increase in health effects can be expected by drinking water with slightly higher than typical background concentrations of uranium, decreasing the amount of uranium ingested may provide valuable peace of mind to those concerned. And, even with slightly higher uranium concentrations, the water is still acceptable for external, household utility use.

Gamma Rays

Gamma rays are bundles of electromagnetic energy which behave as though they were particles. These pseudo particles can be thought of as a bundle of energy called photons. They are similar to visible light, but of a much higher energy. For example, X-rays are a type of high-energy electromagnetic radiation, and excessive exposure to X-rays can damage the body. Gamma rays are generally more energetic than X-rays. They can travel long distances and can penetrate not only skin, but depending on their energy, can penetrate substantial distances into solid materials such as concrete or steel. Gamma rays are often released during radioactive decay along with alpha and beta particles. Some of the materials stored in the K-65 Silos at the FMPC decay by emitting gamma rays. Potassium-40 is an example of a naturally-occurring radionuclide found in all human tissue that decays by emitting a relatively high-energy gamma ray. The typical human body contains about 11 million picocuries of potassium-40. (Units of radiation are discussed on page 53.)

Interaction with Matter

When radiation interacts with other materials, it affects the atoms of those materials principally by knocking the negatively charged electrons out of orbit. This causes the atom to lose its electrical neutrality and become positively charged. An atom that is charged, either positively or negatively, is called an ion. Anything that creates an ion is said to be ionizing.

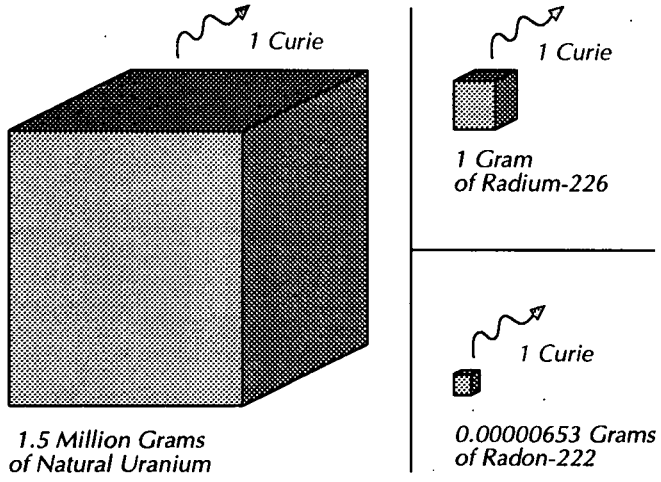
Units of Measurement

To measure the effect of radiation, scientists have developed ways to measure levels and intensity of radiation. Some of these measurement units are technical and may require some explanation. Additional terms are included in the glossary to this report.

Activity

Activity is the number of nuclei in a material that decay per unit of time. An amount of radioactive material which decays at a rate of 37 billion atoms per second has an activity of one Curie (Ci). Smaller units of the Curie are often used in this report. Two common units are the microcurie (μCi), one millionth of a Curie, and the picocurie (pCi), one trillionth of a Curie. The amount of radioactive material to emit one Curie depends on the disintegration rate. For example, about one gram of radium-226 is one Curie of activity, but it would require about 1.5 million grams of natural uranium to equal one Curie, since radium-226 is more radioactive than natural uranium. Radon-222 is more radioactive than radium-226, and only 6.5 millionths of a gram are needed to equal one Curie (Figure 13).

FIGURE 13: Comparison of Disintegration Rate



Dose equivalent

When a person comes into contact with radiation, that person has been exposed to radiation. Exposure is a measure of the amount of radiation that is delivered to the body. Alpha, beta, and gamma radiation affect the body to different degrees. To take these different effects into account, each type of radiation is assigned a quality factor (QF). The more damaging the type of radiation, the higher the QF. For beta and gamma radiation, the quality factor is one. For alpha radiation, the quality factor is 20. A different unit of measurement called the dose equivalent, or simply dose, is used when comparing the effects of different types of radiation. The dose equivalent is expressed in a unit called rem. The more rem, the higher the potential damage. Since the amount of radiation we receive from

In this report, we use the term ***dose*** frequently. Unless specified differently, that term will be used in place of the term ***dose equivalent.***

natural background and the FMPC is so small, millirem (mrem) is often used instead of rem. One mrem is equal to 1/1000 of a rem.

The term dose is used in four different ways in this report: organ dose, effective dose, committed effective dose, and whole body dose.

The organ dose is the amount of radiation received by an individual organ in the body. The amount of radiation any organ will absorb depends upon a variety of factors (for example, the way the radiation entered the body and the type of radiation). Therefore when discussing the organ dose, scientists often refer only to the organ of greatest importance called the critical organ. The critical organ varies from situation to situation. It is chosen based on things such as the amount of radiation received, the chemistry of the radionuclide, the sensitivity of that organ to the particular form of radiation, and the importance of that organ to the body. Based on the radionuclides found at the FMPC, the critical organs have been identified as the lung, kidney, and bone surface (endosteum).

The effective dose expresses how much of a health risk doses of radiation pose to individuals. To determine the effective dose, scientists first estimate each organ dose. Then, since some organs are more sensitive to radiation than others, the organs are given differing weighting factors, similar to quality factors. The greater the risk an organ has of developing cancer and the more important that organ is to human health, the higher the weighting factor. The weighting factor is multiplied by the organ dose for each organ. These numbers are then added together to give the effective dose.

The NCRP and ICRP recommend that an individual be exposed to no more than 100 mrem effective dose per year for all pathways (over and above the amount a person receives from background and medical radiation). This recommendation applies to the general public for long-term, continuous exposures.[17] The DOE guideline for dose to members of the public is 100 mrem per year from all pathways (excluding radon). The National Emission Standards for Hazardous Air Pollutants (NESHAP) limit for effective dose is 10 mrem per year from radionuclides (except radon) released via the air pathway.[15]

The committed effective dose is the total amount of radiation an individual receives over a specified period of time from radioactive materials inside the body. When a person breathes or eats something that contains radioactive materials, the radiation within those materials is not all released at once. Half of the radiation is released over a period of time equal to the half life of the radioactive material. Meanwhile, the body excretes radioactive materials at various rates determined by an

"Remainder" means the five other organs with the highest dose (e.g., liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, or upper and lower large intestine, but excluding skin, lens of the eye, and extremities). The weighting factor for each of these organs is 0.06.

Organ or Tissue	Weighting Factor
Gonads	0.25
Breasts	0.15
Red Bone Marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone Surfaces	0.03
Remainder	0.30

individual's metabolism and the biochemistry of the radioactive material. Scientists have developed the concept of the committed effective dose to estimate the total amount of radiation one will receive over time (generally a 50-year period) from the radioactive materials taken into the body in a given time period.

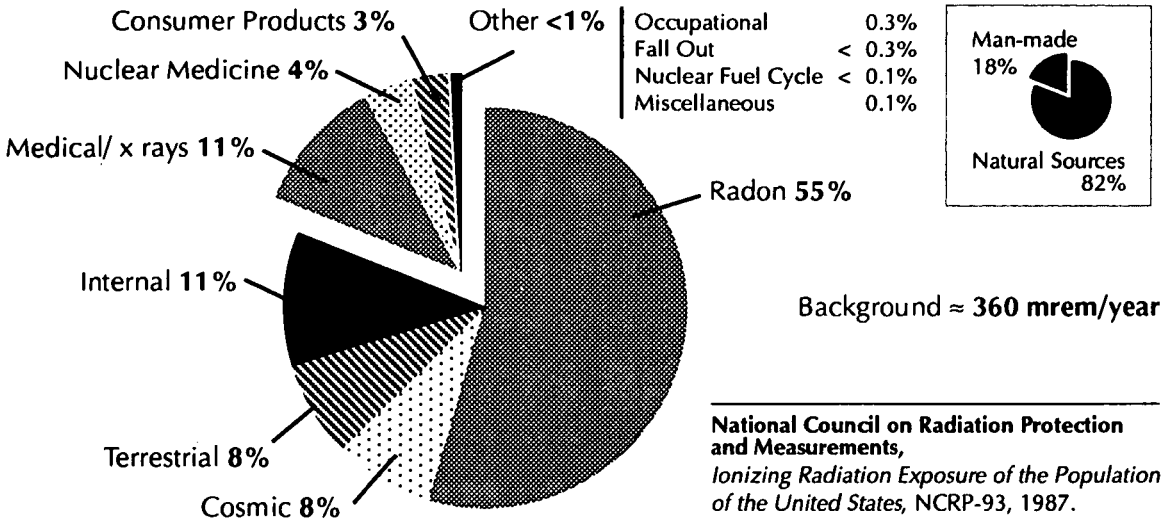
The whole body dose is the amount of radiation an individual receives when the entire body is irradiated evenly by penetrating (gamma) radiation. Most radionuclides present at the FMPC do not contribute toward a whole body dose because they concentrate more in some organs than others and do not emit significant amounts of gamma radiation.

Exposure to Background Radiation

The dose terms defined in the preceding paragraphs apply to more than the radiation we may be exposed to from facilities like the FMPC. We are constantly exposed to what is called background radiation. This includes the decay of radioactive elements in the earth's crust, a steady stream of high-energy particles from space called cosmic radiation, naturally-occurring radioactive isotopes in the human body like potassium-40, medical procedures, man-made phosphate fertilizers (phosphates and uranium are often found together in nature), and even household items like televisions.[18] In the United States, a person's average annual exposure from background radiation is 360 mrem.[17] The DOE guidelines (as well as other radiological guidelines) apply to exposures we receive in addition to background radiation.

As the Background Radiation Chart shows, radon is the largest contributor to background radiation (Figure 14). At an average of 200 mrem per year, naturally occurring radon accounts for more than half of the background dose in the United States.[14]

FIGURE 14: Exposure to Background Radiation Chart



National Council on Radiation Protection and Measurements,
Ionizing Radiation Exposure of the Population of the United States, NCRP-93, 1987.

One way to measure how much radiation we are exposed to is to complete a personal radiation dose counter, like the one on page 57.

The next section provides information on the effects of low-level radiation, whether it is naturally occurring or originates from a facility like the FMPC.

Effects of Radiation

The effects of radiation on humans are divided into two categories, somatic and genetic. Somatic effects are those that develop in the directly exposed individual, including a developing fetus. Genetic effects are those that are observed in the offspring of the exposed person.

Because we are constantly exposed to both natural and man-made sources of radiation, and because the body has the capacity to repair damage from low levels of radiation, it is extremely difficult to determine the effects from low-level radiation. This section explains why this is true and how somatic and genetic effects may occur.

Somatic Effects

Continuous exposure to low levels of radiation can produce gradual somatic changes over extended time. For example, someone may develop cancer from man-made radiation, background radiation, or some

Personal Background Radiation Dose Counter*	
Source of Radiation	**Annual Dose** (mrem)
Earth and Sky Cosmic radiation at sea level	**26**
Cosmic radiation above sea level Add 1 mrem for every 100 feet above sea level (Cincinnati is approximately 600 feet above sea level.)	
Jet plane travel/high altitude exposure to cosmic radiation Add 1 mrem for every 2,500 miles flown	
Radon	**200**
Nuclear testing fallout	**5**
Your Body	**40**
Television Viewing Add 0.15 mrem for each hour of viewing per day (For example, if you watch an average of 4 hours of TV a day in 1990, add 0.6 mrem.)	
Medical X-Ray and Radiopharmaceutical Diagnosis Add 10 mrem for each chest x-ray	
Add 500 mrem for each lower gastrointestinal-tract x-ray procedure	
Add 300 mrem for each radiopharmaceutical examination	
Total	

**The information is drawn from two major sources:*
- *BEIR Report-III-National Academy of Sciences, Committee on Biological Effects of Ionizing Radiations, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences, Washington, DC, 1980 and*
- *National Council on Radiation Protection and Measurements Report No. 93, 1987.*

other source not related to radiation. Because all illnesses caused by low-level radiation can also be caused by other factors, it is presently impossible to determine individual health effects of low-level radiation. However, there are a few groups of people under medical observation because they have been exposed to higher levels of radiation. These include the survivors of Hiroshima and Nagasaki, uranium miners in the

United States and eastern Europe, a group of workers who used paint containing radium, early users of X-ray machines, some Department of Energy employees working in the defense facilities, and people suffering from illnesses where radioactive material was used for treatment. Even after studying the health effects of radiation on these groups, scientists are still not able to determine with certainty how much cancer may have been caused by low-level radiation.

Those exposed to high levels of radiation are at greater immediate risk. We know this because at these higher radiation doses, we see that the number of radiation effects increases as the level of radiation dose increases.

A whole-body dose of 1,000 rem of radiation delivered instantaneously will probably kill a person. A dose of 600 to 1,000 rem causes severe sickness, but there is some chance for recovery. A dose of 200 to 600 rem causes some sickness with a very good chance for recovery. A dose of 100 to 200 rem could possibly cause some vomiting, but probably no demonstrable long-lasting effects.[19] From these very high doses and their affects, scientists try to predict the effects and risks from low levels of radiation.

Significant clinical symptoms of radiation probably won't be seen in individuals who have been exposed to less than 100 *rem*.[20] (The FMPC dose to the maximally exposed individual from all pathways, except radon, was about 10 *mrem* – or 0.01 rem – in 1990.) Most scientists believe that there are no directly observable short-term radiation effects on human beings exposed to less than 10 rem because the biological damage created by this level of radiation is too small to result in near-term clinical symptoms.

Estimates on the value of the threshold level for radiation, if it exists, vary significantly. As mentioned above, some scientists believe it could be as high as 10 rem.[19] Others insist there is no threshold level below which radiation exposure is safe.[21] They feel there is always a direct relation between the amount of radiation to which people are exposed and the number of related radiation effects.

Certain somatic effects have been documented only at high radiation levels. These include clouding of the lens of the eye, lowered fertility rate, and a reduced number of white cells in the blood. Problems caused by radiation seen in the development of the embryo apparently result from large doses, not the low levels characteristic of natural background radiation. Therefore, the most likely somatic effect of low-level radiation is believed to be some increased risk of cancer.[18]

Genetic Effects

A single ionizing event has the potential to cause a genetic effect. To understand why this is true, it is helpful to look at the structure of a human cell.

Human cells normally contain 46 chromosomes; 23 transmitted from the mother and 23 from the father. These 46 chromosomes contain about 10,000 genes which are passed on to the next generation and which determine many physical and psychological characteristics of the individual.

Radiation can cause physical changes or mutations in these genes. Chromosome fibers can break and rearrange, causing interference with the normal cell division of chromosomes by affecting the number and structure. A cell can rejoin the ends of a broken chromosome but, if there are two breaks close enough together in space and time, the broken ends from one break may join incorrectly with those from another. This can cause translocations, inversions, rings, and other types of structural rearrangement.[18] Radiation is not the only mechanism by which such changes can occur. Spontaneous mutations and chemically induced mutations have been observed.

The mutated genes from one parent can then be passed on to offspring. They typically have no effect on the offspring as long as the genes from the other parent are not mutated in the same way. However, the genes stay in the body of the offspring and are passed on to following generations. If they meet similar genes when reproducing, they would then become present in the characteristics of the offspring.[19]

There is no evidence that there are radiation levels below which chromosomes are not affected; however, genetic effects of radiation have never been clearly demonstrated to occur in people.[22, 23]

SUMMARY OF RADIATION FUNDAMENTALS

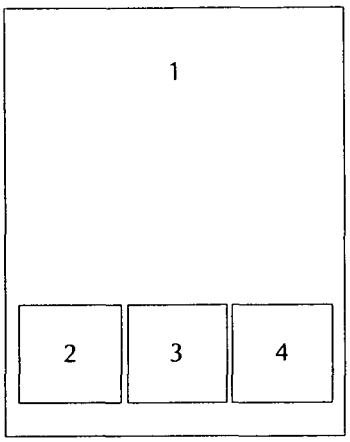
Atoms have two basic parts: the nucleus, a mass of protons and neutrons, and the electrons. Since ordinary matter is electrically neutral, there must be an equal number of positively charged protons and negatively charged electrons in the atom. When the nucleus of an atom spontaneously decays by "throwing off" a particle or additional energy, we refer to this as radioactivity. Therefore, radiation refers to the energy that is released from this decay in the form of alpha particles, beta particles, or gamma rays. We use the term *Curie* as a measure of the activity of a radioactive substance and the term *rem* to express the amount of dose a person receives when exposed to radiation. *Dose* is defined in four different ways: organ dose, effective dose, committed effective dose, and whole body dose.

These terms apply to more than just the radiation that facilities like the FMPC produce. We are constantly being exposed to low levels of radiation produced by everyday things such as the earth, a television set, or the sun. This is called background radiation. The effects of the radiation that we are exposed to can be categorized into two types: somatic and genetic. Those people exposed to very high levels of radiation undoubtedly face a greater immediate risk of illness, cancer, or death, but scientists are unable to determine whether an increase in low-level radiation increases the number of radiation effects.

The FMPC environmental monitoring data are presented in the next three chapters. Along with this information are descriptions of the methods used to gather data. Using this information and a basic understanding of radiation, we can proceed to Chapter Seven for a discussion of the estimated radiation doses to which the people near the FMPC might be exposed and how these results were calculated.

2800

CHAPTER 4



1 – Airborne pollutants may accumulate in the food chain through soil, produce, dairy products, and meat.

2 – Air monitoring stations collect data on radionuclide concentrations in the air at fixed onsite and offsite locations.

3 – Soil is sampled along with produce to see if uranium is accumulating at offsite locations.

4 – Locally grown tomatoes, corn, beans, potatoes, and other crops are routinely sampled to monitor for potential uranium contamination.

CHAPTER FOUR

Air Pathway Monitoring Results

In order to gain a detailed understanding of the effects of past production, current cleanup, and ongoing storage operations on the surrounding environment, the FMPC collects samples of air, water, soil, and other media to measure the amounts of various radioactive and nonradioactive materials that leave the site. The results of the measurements serve several purposes: to determine if the FMPC complies with applicable environmental standards and guidelines, to assess the site's impact on the environment, and to estimate radiation doses to the people living in the surrounding area.

Overall, these measurements indicate that FMPC emissions and discharges, as well as concentrations of radioactive and nonradioactive materials present in the surrounding environment, were well below applicable standards and guidelines established by federal and state laws.

The guidelines presented in DOE Order 5400.1 for the content and format of the Annual Environmental Report state that radiological data be presented in Curies and not Becquerels, the Systeme International unit for radiological data. To simplify the discussion in the text, data will be presented in Curies (generally picocuries). Picocuries can be converted to Becquerels by multiplying by 0.037.

This chapter focuses on the air pathway, including sampling methods and results from air monitoring stations, soil sampling, grass sampling, produce sampling, and milk sampling. Also reported are results from the radon monitoring program and the nonradioactive boiler plant emissions. Often, 1990 results are compared to data from 1988 and 1989.

Results in Brief: 1990 Air Pathway

The FMPC continued its extensive monitoring of the air pathway during 1990. In general, the data from this monitoring program were either consistent with or lower than last year's results. Each component of the air pathway is discussed in detail in this chapter; the results are summarized below.

Air – Data collected from fenceline and offsite air monitoring stations show that average concentrations of uranium and trace radionuclides were all less than 1% of the DOE standard. Airborne uranium emissions for 1990 were estimated to be 3.2 kg, lowest in the history of the site.

Soil – Uranium concentrations were consistent with previous years' data. Some sampling locations northeast of the site had total uranium concentrations up to 7.2 pCi/g, which is above the background level of about 4.4 pCi/g for this area of Ohio.[24]

Grass – 1990 uranium concentrations were lower than 1989 data at all but two of the 30 locations, and those increases were slight.

Produce – Uranium concentrations were consistent with previous years' data. There were no significant differences in uranium concentrations between produce grown near the plant and produce grown several miles from the plant.

Milk – In general, uranium concentrations were consistent with previous years' results of less than 0.68 pCi/L. However, samples for several months from *both* the local dairy and the dairy located in Indiana had detectable concentrations of uranium. It is not clear what is causing sporadic detectable uranium concentrations in the milk samples.

Radon – Concentrations along the FMPC fenceline were essentially the same as in 1989, and conditions affecting radon emissions from the FMPC did not change.

Boiler plant – All emissions were well below permit limits.

Monitoring for Radioactive Pollutants

As discussed in Chapter One, a potential source of radiation exposure to the public from the FMPC is through the air pathway. This includes emissions from specific point sources (such as plant stacks), as well as dust from large open areas like the waste pit area (known as fugitive dust). The suspension of production in 1989 essentially eliminated production emissions. However, some waste materials were processed during 1990 before they were shipped offsite. This processing resulted in extremely minor emissions, which were estimated at 0.089 kg; this was less than 3% of the 1990 total estimated airborne emissions of 3.2 kg (7 pounds). Now that production has ended, potential sources of airborne contamination are fugitive dust blowing from the waste pit area or from where environmental cleanup activities are underway.

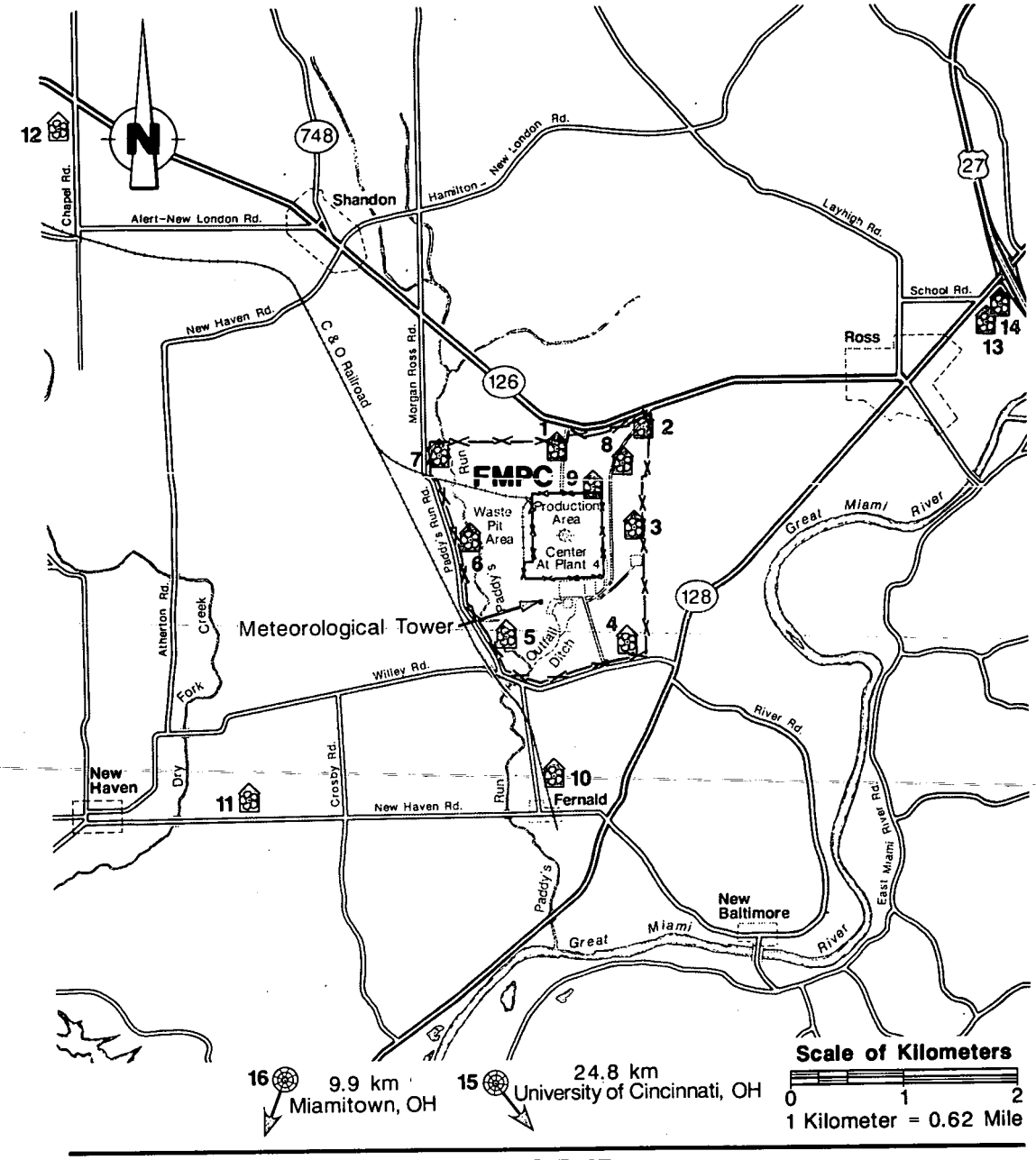
The FMPC continues to monitor the primary components of the air pathway by sampling air, soil, grass, produce, and milk. This will help enable scientists to determine the effects of the cleanup efforts at the site, as well as fulfill the site's obligations toward ongoing environmental surveillance and dose estimation. The following sections describe the air pathway sampling programs.

Air Sampling for Radioactive Particulates

In order to obtain accurate information about the amounts of uranium and other radionuclides in the air, the FMPC operates 16 continuous, high-volume air monitoring stations (AMS). The locations for the air monitoring stations, as shown in Figure 15, were selected for several reasons:

- AMS 1 through 7 provide data at the FMPC fenceline because this is where the public has closest access to the site and guidelines for offsite exposure take affect;
- AMS 8 and 9 are in the prevailing wind direction at the FMPC. They were added in 1986 in the northeast sector of the site based on a computer model that predicted where the highest ground-level concentrations of airborne uranium from FMPC operations would be found. AMS 13 and 14 are also located in the same quadrant but farther from the center of the site (Ross, Ohio);
- AMS 15 and 16 were installed in 1989 to obtain additional background data — AMS 15 is located near the University of Cincinnati in Corryville, Ohio; AMS 16 is located in Miamitown, Ohio; and
- AMS 10, 11, and 12 measure radionuclide concentrations in nearby communities.

FIGURE 15: Air Monitoring Locations



LEGEND

- Air Monitoring Location
- Distance from Center of Production Area to Sampling Locations off Map
- Plant Perimeter
- Production Area Perimeter

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At each AMS, air is drawn through a 20 cm by 25 cm (8 inch by 10 inch) filter at a rate of about 1 m^3/min (about 35 ft^3/min). Technicians account for any changes in flow rate over the sampling period by inspecting charts which continuously record flow data.

The filters from the air monitoring stations are collected and analyzed at weekly intervals. At the laboratory, technicians store the filters for at least three days following collection to allow naturally occurring, short-lived radionuclides such as radon to decay. (This holding period does not affect the amount of uranium on the filters.) After the holding period, the filters are heated to 550°C (1,022°F) to remove organic matter. Finally, these filters are dissolved in acid, and the resulting solutions are analyzed for uranium. A portion of each of these solutions is retained each week to prepare a yearly composite which is then analyzed for trace radionuclides such as isotopes of radium, neptunium, plutonium, and thorium.

The average concentrations of uranium at the seven fenceline (AMS 1 through 7) and seven offsite (AMS 10 through 16) air monitoring stations were all less than 1% of the DOE guideline. Table 1 lists 1990 data for uranium concentrations. (All tables can be found in Appendix A.) Figure 16 compares uranium concentrations at the air monitoring stations for 1988 through 1990.

Over the past several years, the average concentrations of trace radionuclides (those presented in Table 2) have been decreasing. In fact, an increasing number of radionuclides have been "less than detectable"* at ***all*** air monitoring stations. Those radionuclides by year are:

1987: ruthenium-106

1988: ruthenium-106, cesium-137

1989: ruthenium-106, cesium-137, thorium-232

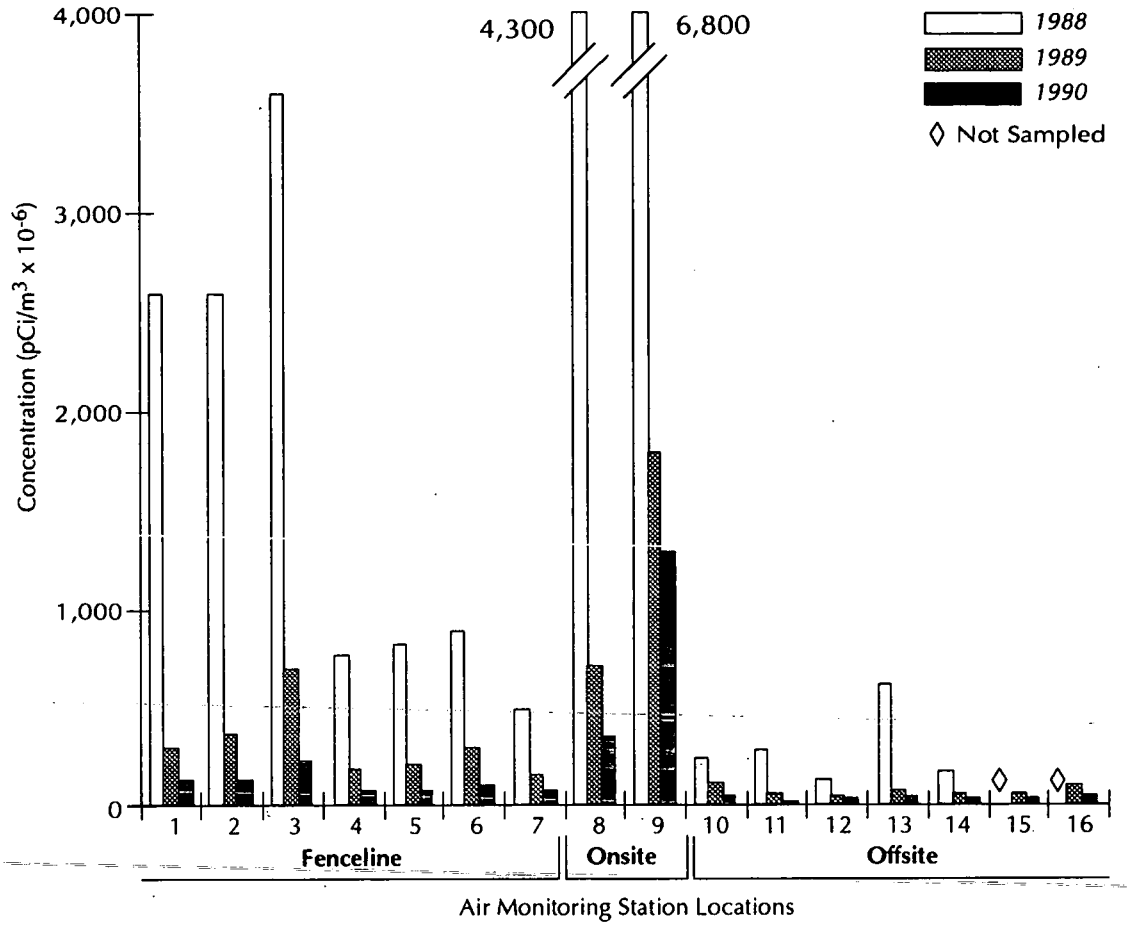
1990: ruthenium-106, cesium-137, thorium-232, radium-228, neptunium-237, plutonium-238, plutonium-239/240.

In 1987 and in 1988, all radionuclides except uranium-234 and uranium-238 had average concentrations of less than 1% of the Derived Concentration Guide for all stations. By 1989 and continuing in 1990, the average concentrations of all radionuclides, including the uranium isotopes, were less than 1% of the DCG.

* "Less than detectable" is explained in Appendix A, page 1.

The concentrations of trace radionuclides also continued trending downward during 1990. The concentrations of all trace airborne radionuclides were less than 1% of the DOE guideline (Table 2).[13] Concentrations of thorium-232, measured at the air monitoring stations, for 1988 through 1990 are presented in Figure 17.

FIGURE 16: Average Uranium Concentrations in Air, 1988 to 1990

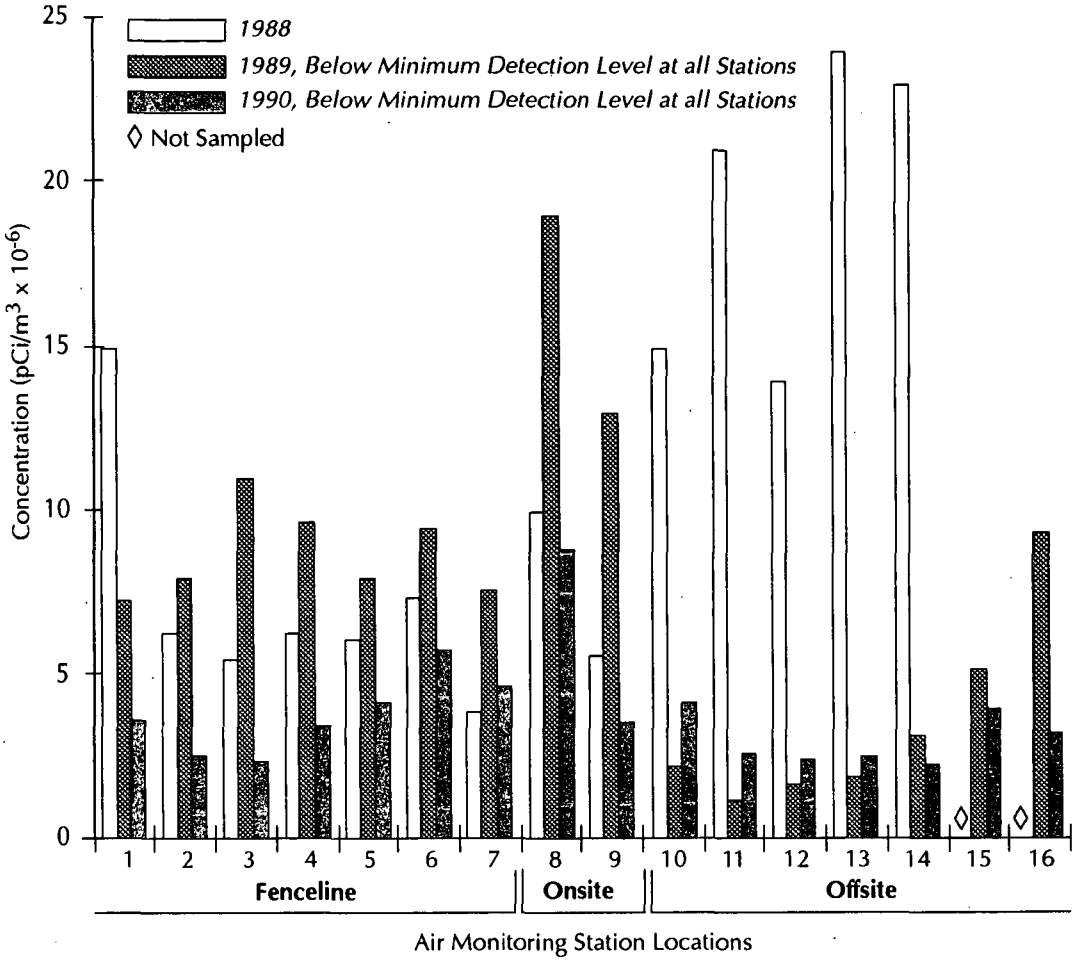


Soil Sampling for Uranium

The FMPC takes annual soil samples at the air monitoring stations and offsite locations to determine if soil uranium concentrations in the area are changing (Figure 18). There is a wide variability in the amount of uranium naturally present in rocks and soils. For example, the average uranium concentration in limestone is about 0.88 pCi/g; in normal granite it is 2.7 pCi/g; and in phosphate rock from Florida the average uranium concentration is 82 pCi/g. Consequently, uranium concentrations in phosphate fertilizer are generally high.[19] (The FMPC laboratory analyzed one sample of fertilizer in 1990, and the uranium concentration was 24 pCi/g.)

In one study, researchers analyzed 355 soil samples collected from 33 states for uranium-238. The concentrations ranged from a Florida soil

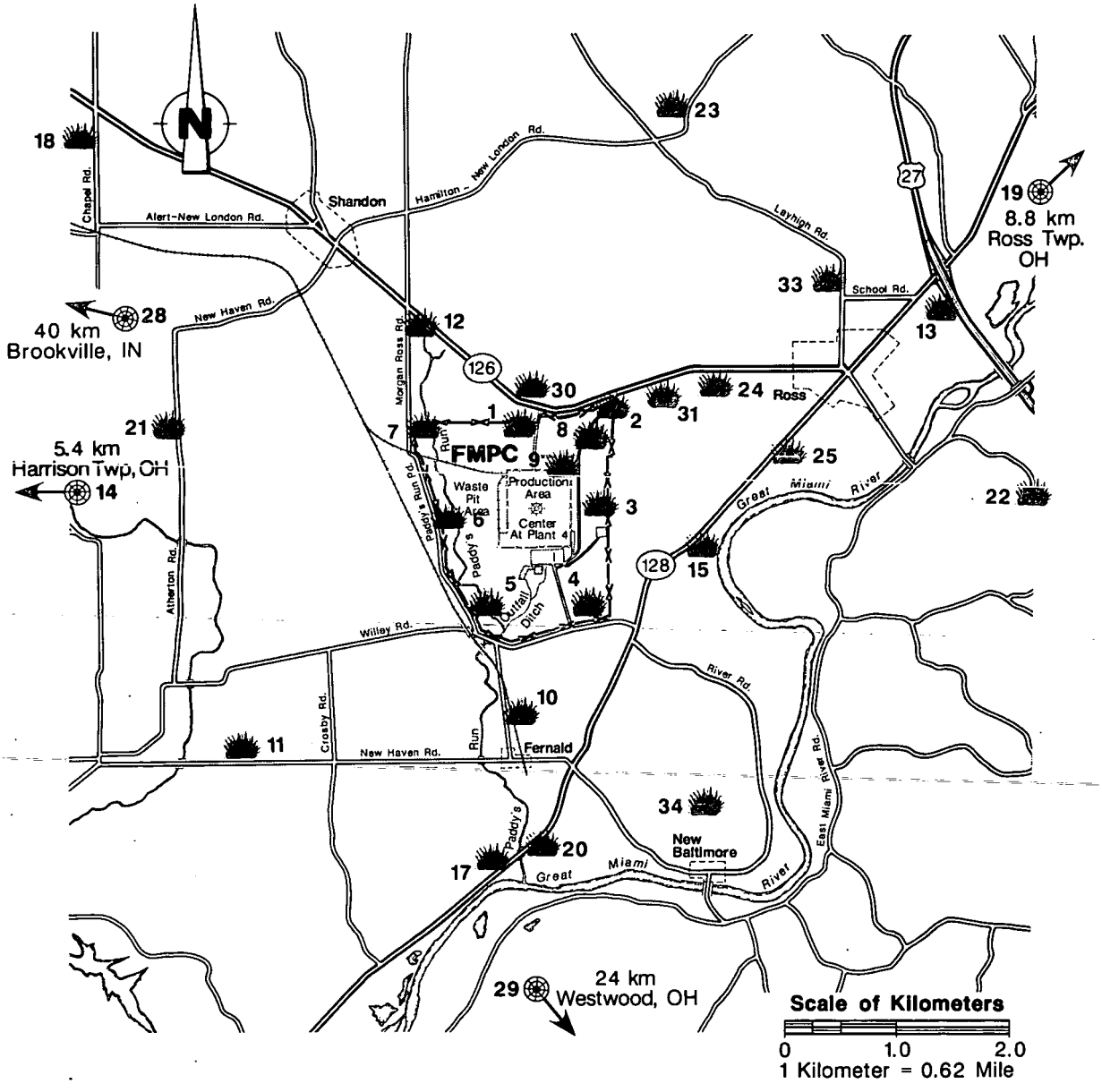
FIGURE 17: Average Thorium–232 Concentrations in Air, 1988 to 1990



sample of 0.12 pCi/g to a high of 3.8 pCi/g from a sample collected in Kentucky. Twelve samples were collected throughout Ohio; the range of uranium-238 concentrations was 0.76 pCi/g to 2.2 pCi/g.[24] Total uranium activity would be about twice these amounts because naturally occurring uranium in soil typically contains equal amounts of uranium-238 and uranium-234 radioactivity.

Because of the variability in the amount of uranium and minerals naturally present in rock and soil, it is not possible to establish a single value for the background level of uranium and other minerals for an area, such as near the FMPC. As a result, no DOE or USEPA guidelines or standards have been established. However, to assist sites like the FMPC in their cleanup efforts, the DOE and USEPA have agreed that an acceptable level at which to begin cleanup activities for uranium in soil is 35 pCi/g, based on potential dose. [25]

FIGURE 18: Soil and Grass Sampling Locations



LEGEND

- Sampling Location
- Distance from Center of Production Area to Sampling Locations off Map
- Plant Perimeter
- Production Area Perimeter

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To better evaluate the significance of the uranium concentrations in soil samples collected for the Environmental Monitoring Program, the FMPC is funding a study to determine the amount of uranium naturally present in soil near the site. The study will continue during 1991.

As part of the FMPC soil sampling program, technicians collect cores of soil from undisturbed plots at two depths, 0-5 cm (0-2 inches) and 5-10 cm (2-4 inches). Care is taken to exclude grass from the soil samples. Results from 1990 show that uranium concentration in the soil samples taken along the fenceline ranged from less than 2.9 to 15 pCi/g dry weight at the 0-5 cm depth (Table 3). The uranium concentration in offsite samples ranged from 1.1 to 7.2 pCi/g dry weight.

The FMPC performed a statistical evaluation of the 1990 data to determine if uranium concentrations in the soil were relatively higher at locations closer to the plant. In 80% of the circular area around the FMPC, concentrations appeared to be randomly distributed with no pattern of above-background uranium concentrations in samples collected near the site. However, a strong correlation between relative distance and relative concentration was found in the sector north to east-northeast of the FMPC. In an effort to explain this correlation, it was noted that although the north to east-northeast sector represents only 20% of the circular area, it is downwind of the site over 35% of the time, based on wind rose data for the previous 30 years.[26]

For soil, 1 µg uranium/g = 1 ppm = 0.68 pCi/g; 1 pCi uranium/g = 1.48 ppm.

Grass Sampling for Uranium

Samples of grass were collected at the same locations as soil. Each grass sample was a composite of at least three subsamples clipped near ground level. The composite samples each weighed about 500 grams. An offsite laboratory air-dried and analyzed the samples for uranium.

In addition to soil sample results, Table 3 reports the following uranium concentrations in onsite and offsite grass samples:

- Fenceline results ranged from 0.0051 to 0.28 pCi/g dry weight,
- Offsite results ranged from 0.00029 to 0.0084 pCi/g dry weight.

Standards have not been established for uranium in grass; however, the data for 1990 show a considerable overall decrease in uranium concentrations when compared to results from previous years. Only two fenceline sampling locations, AMS 4 and AMS 7, had higher uranium concentrations than last year, and the increases were only 0.02 pCi/g and 0.01 pCi/g, respectively.

Produce Sampling for Uranium

As mentioned in Chapter One, the FMPC is surrounded by fertile farmland. Sweet corn and tomatoes are two of the major crops sold from roadside stands within three miles of the FMPC. Beets, potatoes, apples, lettuce, pumpkins, cucumbers, and peppers are among the other fruits and vegetables grown and sold near the plant. The FMPC samples produce every year to compare uranium concentrations to determine if the amount of uranium is increasing or decreasing over time. Data from locations near the plant are also compared with data from locations several miles from the site. This is done to determine if uranium concentrations in locally grown produce have been significantly affected by FMPC airborne discharges. The concentrations are then used to estimate the potential dose to people from this component of the air pathway (see Chapter Seven).

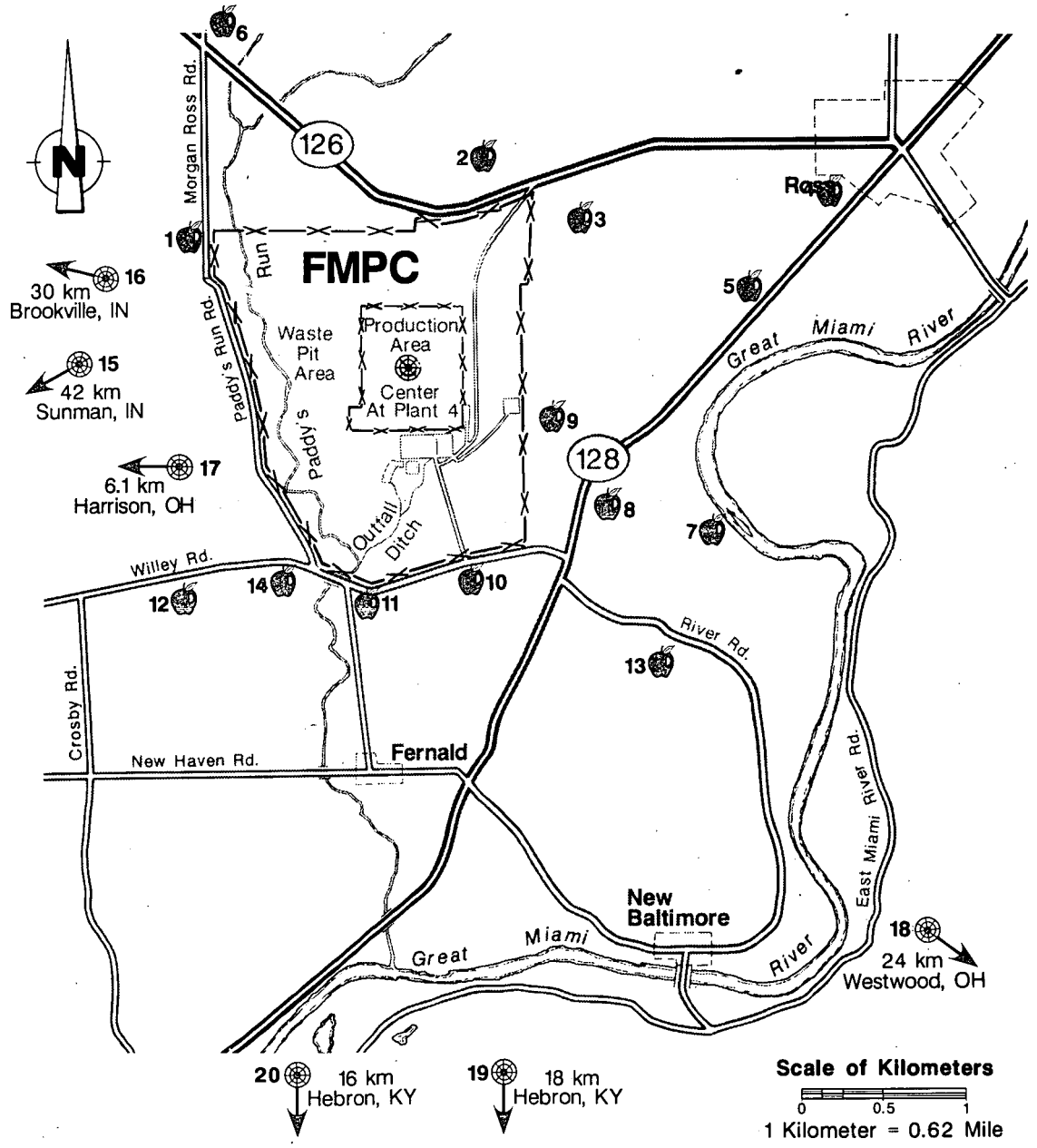
With air emissions reduced to very low levels, the possibility of uranium contamination in produce, caused by air deposition, is also very low. While washing the produce before eating removes the surface contamination, some uranium may be taken up by plants through their root systems and incorporated in their edible portions. Any uranium from the soil may be naturally occurring, added by fertilizers, or a result of FMPC operations.

Environmental Monitoring personnel sampled produce (and soil, where possible) from 15 farms and gardens within 6.1 km (3.8 miles) of the center of the site. To determine background uranium concentrations, the FMPC also collected samples from five farms located between 16 km (10 miles) and 42 km (26 miles) from the site (Figure 19).

The results of the produce and soil sampling program are reported in Table 4. In general, uranium concentrations varied greatly for each type of produce and with distance from the plant. Tomatoes collected at Location 2, just north of the site and in the predominant wind direction, had the highest uranium concentration for 1990. However, produce collected from locations closest to the site did not always have the highest uranium concentrations. For example, the uranium concentrations were higher in potatoes grown at background locations than in potatoes grown near the plant. Uranium concentrations in peppers were consistent, except for Location 1 (relatively near the plant) where the concentration was significantly lower.

Uranium concentrations in the soil taken along with produce ranged from 1.5 to 7.2 pCi/g, and were similar to the results of the routine soil sampling program. As with uranium concentration in tomatoes, the highest uranium concentration in soil was also found at Location 2. Chapter Seven presents information on the potential dose from eating produce

FIGURE 19: Produce Sampling Locations



LEGEND

- Sampling Location
- Distance from Center of Production Area to Sampling Locations off Map
- Plant Perimeter
- Production Area Perimeter

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grown near the FMPC, including tomatoes from Location 2. This dose was very small and differed little from the potential dose from eating produce grown at background locations.

Milk Sampling for Radionuclides

Analysis of the air-to-grass-to-cow-to-milk pathway is important for several reasons:

- A single cow can graze a relatively large surface area every day,
- A commercial herd grazes on land immediately adjacent to the FMPC,
- Milk is rapidly transferred from producer to customer, and
- Milk is an important staple in the American diet.

Even though uranium is not normally concentrated in cows' milk, the FMPC examines this component of the air pathway. Furthermore, the FMPC samples a local dairy's milk in response to public concerns.

In 1990, the FMPC sampled milk produced by cows grazing on land adjacent to the site as well as milk from a dairy in Indiana about 37 km (23 miles) west of the FMPC. Data are reported in Table 5.

Milk results from August through December 1990 reflect an increased sensitivity in laboratory analysis, which is now below the previously reported minimum detection limit of 0.68 pCi/L. In general, the limited amount of data reported with increased sensitivity do not indicate any difference between the uranium concentrations in milk from the local and control dairies.

However, results of the milk sampling program from April through June and the quality control results for milk (reported in Chapter Eight) indicate that there were difficulties in consistently obtaining reliable results for uranium analyses in milk. This problem is evident as both the local and control samples show sudden increases in uranium concentration in April, but return to concentrations below the laboratory detection limit by July. The corresponding air monitoring station results for this period show no elevated uranium concentrations — in fact, there were no major airborne releases of uranium during 1990, and estimated emissions were the lowest in the history of the site. Finally, uranium concentrations in grass were much lower than last year. Therefore, one can conclude that the periodic positive uranium results for milk samples from the local dairy were not caused by uranium releases from the FMPC. Rather, these inconsistent results reflect the fact that problems occasionally occurred in the sampling or laboratory analyses of 1990 milk samples.

Such sampling problems could have been caused by using contaminated containers or by contamination of the samples between the time of collection and analysis. In an effort to eliminate such contamination, the FMPC now collects milk in containers which are certified to be free of uranium contamination. The FMPC continues to work with all parties involved in the milk sampling and analysis program in an effort to improve the reliability of the data.

The Radon Monitoring Program

Radon is monitored as a separate component of the air pathway. This is done because radon, being a gas, is a unique component of the air pathway. In contrast, airborne particulates are the major source of the radionuclides in the soil, grass, produce, and milk components of the air pathway. Radon is produced naturally, and breathing high concentrations of radon and its decay products over a period of time has been associated with increased health risks. In addition, radon is produced by waste materials stored in the K-65 Silos, Silo 3, and the waste pits.

To measure changes in radon concentration over time periods much shorter than three months, the FMPC uses *real-time monitors.* These monitors, located primarily near the K-65 Silos, provide hourly average radon concentrations. The data from these monitors are not included in this report; instead, they are used as a health and safety guide for employees working near areas with potentially high concentrations of radon.

To determine radon concentrations in the environment, the FMPC uses *alpha-track radon detectors* in weatherproof housings. An alpha-track radon detector is a device for measuring radon concentrations in air over long time periods. All environmental radon data reported in the 1990 AER are from the alpha-track radon detectors.

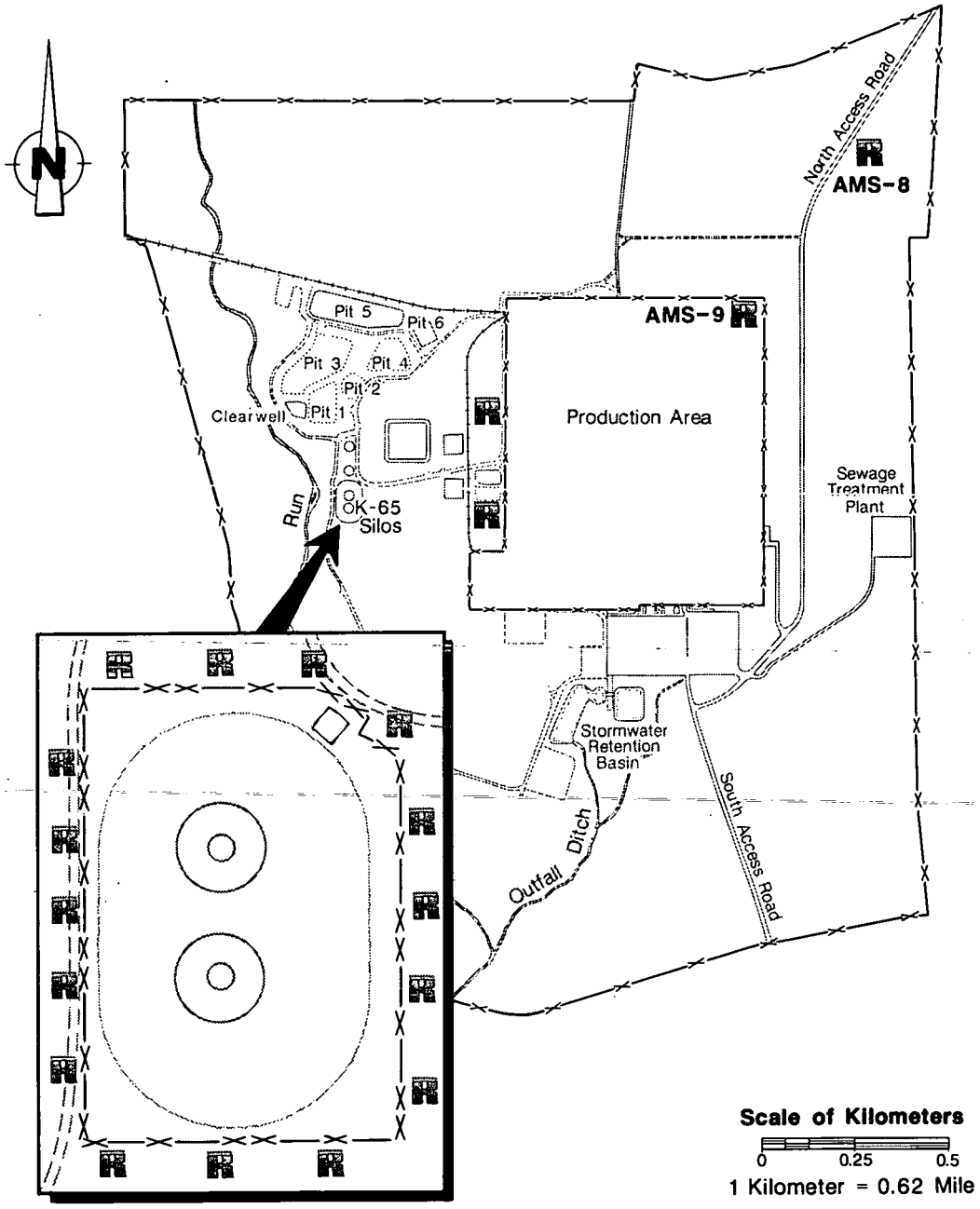
Environmental Monitoring personnel placed either two, three, or six alpha-track-type radon detectors at each of the locations shown in Figures 20 and 21:

- Eleven locations offsite,
- Twenty-one locations along the fenceline,
- Four locations onsite at various distances from the silos, and
- Sixteen locations immediately adjacent to the K-65 Silos.

The 11 offsite locations included four of the offsite air monitoring stations (Figure 15), three outdoors at nearby residences, and four at background locations more than 10 km (6 miles) from the FMPC in the two least prevalent wind directions.

The detectors are changed each calendar quarter and sent to the supplier for analysis. The average quarterly radon concentration at each location was computed from the results for all detectors at that location. The

FIGURE 20: Onsite Radon Monitoring Locations



LEGEND

- Onsite Locations
- K-65 Silos Area Perimeter
- Plant Perimeter
- Production Area Perimeter

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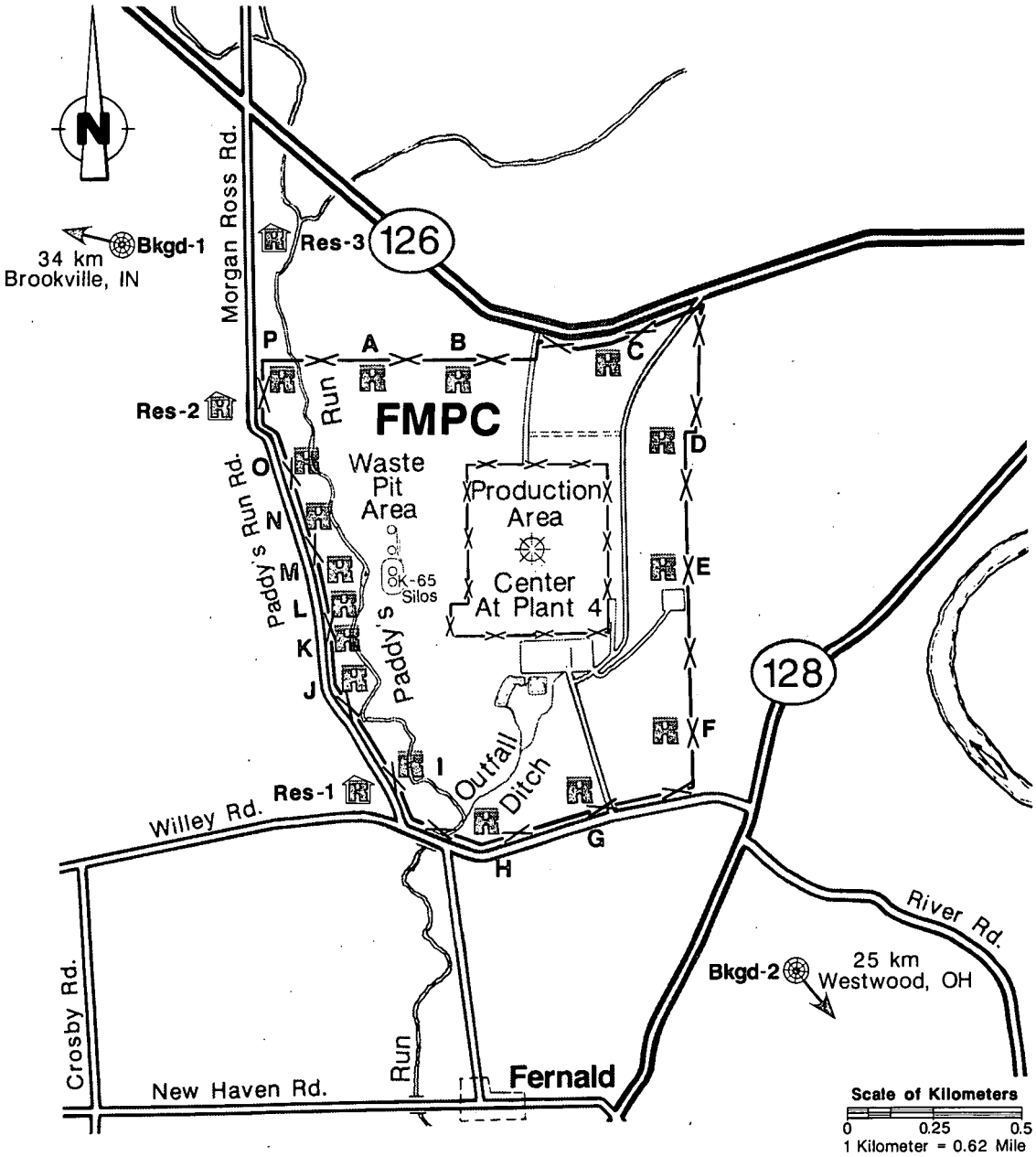
FIGURE 21: Offsite and Fenceline Radon Monitoring Locations



LEGEND

- Fenceline Locations
- Offsite Locations
- Distance from Center of Production Area to Monitoring Locations off Map
- Plant Perimeter
- Production Area Perimeter

1302

annual average radon concentration at each location was then calculated from the quarterly averages.

Table 6 lists the average concentrations for all 21 fenceline monitoring locations, the four background locations, and the average net radon concentration at the fenceline for 1990. The 1990 average fenceline concentrations are very similar to those in 1989. The net concentration of 0.23 ± 0.28 pCi/L indicated that the concentrations measured at the fenceline were well within DOE guidelines which specify that emissions of radon to uncontrolled areas must be at average concentrations of less than 3.0 pCi/L above background concentrations.

Data precision for the alpha-track monitors in 1990, while improved over most previous years, was not as good as in 1989. As a result, the net average fenceline radon concentration in 1990 of 0.23 pCi/L has a standard deviation of ± 0.28 pCi/L and is therefore not statistically distinguishable from background. Nevertheless, the 1990 net average value will be treated as a reliable measure of fenceline radon concentrations for the following reasons:

- The 1990 net average value is very close to the statistically significant 1989 net average value of 0.24 pCi/L,
- Conditions affecting radon emissions at the FMPC did not change substantially from 1989 to 1990, and
- Several real-time radon monitors installed at the FMPC fenceline during 1990 have recorded statistically significant increases above background concentrations for short periods of time.

The FMPC calculated the dose which could be received from radon based on the average net concentration of 0.23 pCi/L at the fenceline. This is described in Chapter Seven.

The highest radon concentration at the fenceline is in the area monitored by the six sampling locations closest to the K-65 Silos along Paddy's Run Road (FMPC J through O in Figure 21). The 1990 average net (above-background) radon concentration at these locations was 0.28 pCi/L, the same as in 1989, which was 10% of the DOE guideline of 3.0 pCi/L above background. Although the data indicated that the west fenceline concentrations were above background, those concentrations were less than the average indoor radon concentration for houses in the United States as reported by the USEPA. The USEPA has set an action limit of 4.0 pCi/L for indoor radon concentrations.

Monitoring for Nonradioactive Pollutants

Analysis of emissions from the FMPC Boiler Plant is required by the OEPA in order to operate such facilities and to demonstrate compliance with statutes such as the Clean Air Act. In addition, grass samples are collected and analyzed for fluoride since it was once a significant part of the production process.

Monitoring Boiler Plant Emissions

The FMPC estimated nonradioactive pollutants including sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and the shade or density of emissions from the coal-fired boilers. Shade or density is also called opacity and is a measure of how much light is blocked by particulates present in stack emissions.

The FMPC checks the sulfur content and heat content of the coal on a regular basis. For 1990, SO_2 emissions were 307,000 kg (677,000 pounds).[27] This was well below the allowable limit of 1.6 million kg or 3.5 million pounds stated in the Permit to Operate issued by the OEPA.

The NO_x emissions from the Boiler Plant for 1990 were 148,000 kg (326,000 pounds). The State of Ohio has not established NO_x emission limits for FMPC industrial process sources since the site is located in a region of the state which is exempt from such limits. At the FMPC, electrostatic precipitators control particulate emissions from the Boiler Plant, which were estimated to be 15,400 kg (34,000 pounds) for 1990. These were based on emission factors developed from stack testing in 1988. The emissions from the two FMPC coal-fired boilers were continuously monitored by instruments designed to measure opacity. During 1990, the boilers operated 12,526 hours and 125,260 measurements were made during six-minute periods. Only four of these measurements failed to meet the

The OEPA maintains an inventory system for actual air emissions from major point sources; the inventory is reported by Southwestern Ohio Air Pollution Control Agency. The most recent data tabulated by SWOAPCA are from 1989, while the FMPC data reflect 1990 emissions (in kg).

	Hamilton Co.	Butler Co.	Combined Counties	FMPC
Particulates	3,592,512	3,108,067	6,700,579	15,400
SO_2	102,285,893	11,863,454	114,149,347	307,000
NO_X	38,907,086	5,254,502	44,161,589	148,000
CO	5,537,456	18,061,141	23,598,597	52,900

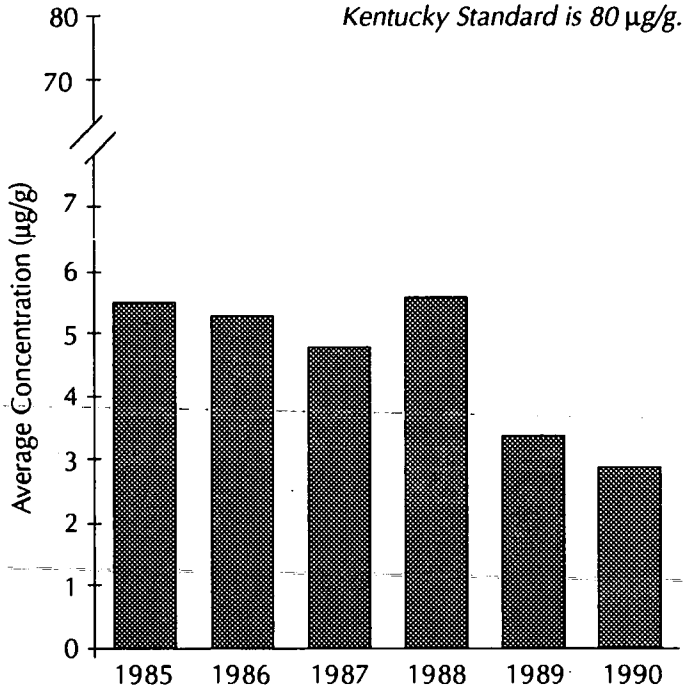
This year's FMPC boiler plant emissions reflect only 0.23% of the counties' combined 1989 particulate emissions, 0.27% of the combined SO_2 emissions, 0.34% of the combined NO_X emissions, and 0.22% of the combined CO emissions.

opacity standard. Results of all 1990 opacity measurements were reported to Southwestern Ohio Air Pollution Control Agency.

Grass Sampling for Fluoride

A second offsite laboratory analyzed the grass samples for fluoride because the FMPC used hydrogen fluoride and generated magnesium fluoride as part of the production process. Fluoride in grass is regulated to protect grazing livestock. The FMPC will discontinue fluoride analysis after 1990, since production has ceased and fluoride concentrations have consistently been less than 6% of the 80 µg/g Kentucky standard (used in the absence of an Ohio standard). In 1990, the average concentration was less than 2.9 µg/g (less than 3.6% of standard), and the maximum concentration was only 4.6 µg/g (less than 5.8% of standard) as shown in Figure 22.

FIGURE 22: Average Fluoride Concentration in Grass

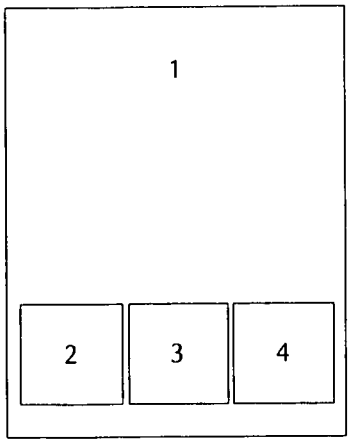


SUMMARY OF AIR PATHWAY MONITORING RESULTS

Airborne uranium emissions for 1990 were the lowest in the history of the site. And, in general, air pathway monitoring results were lower than results for 1989. Fenceline uranium concentrations were lower compared to 1989 data, and fenceline radon concentrations were similar to those measured in 1989. Some onsite and nearby offsite soil samples continue to indicate some deposition of airborne particles from past operations. While produce and grass samples indicated no measurable contributions via the air pathway in 1990, problems with obtaining reliable data for the milk sampling program continued.

In addition to directly affecting concentrations of contaminants in soil, grass, and other media discussed in this chapter, the air pathway can indirectly influence contaminant concentrations in the liquid pathway. Stormwater runoff is one way materials deposited from the air can be transported into surface water such as Paddy's Run. Eventually, these contaminants may affect groundwater quality as well. The next two chapters describe the FMPC's monitoring program for the liquid pathway beginning with Effluent and Surface Water Monitoring in Chapter Five.

CHAPTER 5



1 – Paddy's Run flows south through the site property and is a tributary to the Great Miami River.

2 – Sediment from Paddy's Run and the Great Miami River is routinely sampled and monitored for uranium and other radionuclides.

3 – Electrofishing is the best method for collecting fish samples unbiased with respect to size and species.

4 – Special surface water samples are collected as part of the Environmental Monitoring program.

CHAPTER FIVE

Liquid Pathway: Effluent and Surface Water Monitoring Results

Because radionuclides and chemicals may be present in its regulated liquid effluents and uncontrolled stormwater runoff, the FMPC investigates the effects of past and current operations on a second major pathway — the liquid pathway. Since contaminants can leave the site through these components of the liquid pathway, this chapter discusses sampling methodologies and results used to evaluate the FMPC's effluents and to determine any impacts from the FMPC on the Great Miami River and Paddy's Run. Groundwater, another major component of the liquid pathway, is discussed in the next chapter.

Results in Brief: 1990 Liquid Pathway: Effluent and Surface Water

Even though production had ended, the FMPC continued to closely monitor the liquid pathway during 1990. Indeed, monitoring efforts intensified as cleanup activities increased. For example, projects to reduce radionuclide concentrations in the effluent and to increase the area of controlled stormwater runoff progressed. Each component of the liquid pathway is discussed in detail in this chapter; the results are summarized below.

Effluent – About 786 kg of uranium was discharged to the Great Miami River during 1990; this was a slight reduction compared to 1989. Uranium, thorium-230 and -234, and strontium-90 were the only radionuclides detected in the effluent to the river.

Surface water – The liquid effluent discharged to the river resulted in a slight increase in uranium concentration downriver from the effluent line, but these concentrations were less than 0.1% of the DOE guideline. The uranium concentration in Paddy's Run continued to show some effects of stormwater runoff from the site; the average uranium concentration at the nearest offsite sampling location was the same as in 1989 — 1.2% of the DOE guideline.

Sediments – Radionuclide concentrations in the Great Miami River and Paddy's Run sediments for 1990 were consistent with previous years' data and did not indicate a buildup of radioactive pollutants in the sediment.

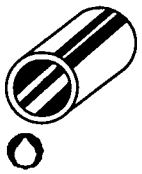
Fish – Uranium concentrations were no greater in fish caught downstream of the FMPC effluent line than in those caught upstream, and the fish appeared healthy.

NPDES – OEPA issued a new permit in February, and the site complied with the more restrictive limits 99% of the time during 1990.

Surface water quality – Concentrations of fluoride, nitrate-nitrogen, and chloride and pH values in the river and Paddy's Run showed little or no effect from FMPC operations.

Monitoring for Radioactive Pollutants

Like the air pathway, the liquid pathway can carry both radioactive and nonradioactive contaminants offsite. Figure 23 shows the relationship of the FMPC's effluents to the local surface water systems. The first section of the chapter centers on the radioactive pollutants and begins with an examination of the liquid effluent sampling and analysis program. A discussion of the river and creek surface water sampling program follows. The FMPC conducts these programs because radionuclides in the regulated effluent discharge and in stormwater runoff may be a source of radioactive exposure to the public.



Effluent Sampling for Radionuclides

The FMPC's liquid effluents originated from four sources:

- Process wastewater,
- Sanitary sewage,
- Controlled stormwater runoff, and
- Wastewater from the water treatment plant and coal pile runoff.

Figure 24 illustrates the flow of the effluents and where they are treated before they are discharged to the river.

Sources of Effluent During 1990

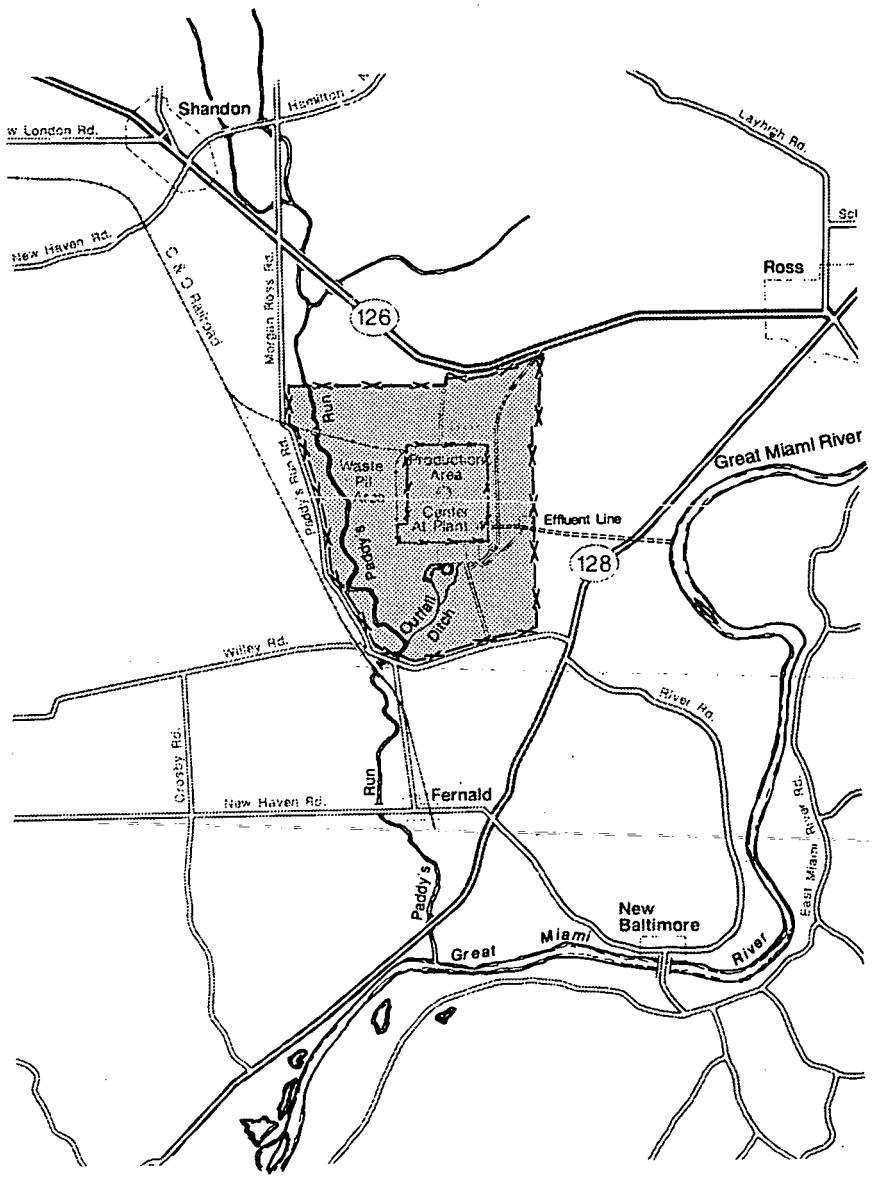
The first source of liquid effluent is ***process wastewater and controlled stormwater runoff from the waste pit area.*** Process wastewater is collected and treated in various buildings and controlled storage areas in the former production area to reduce radioactive and chemical contaminants. Stormwater runoff that is controlled in the waste pit area is sent either directly to the Biodenitrification Surge Lagoon (BSL) or is collected in the clearwell from which it is pumped to the BSL. This change took place during September 1990. Before, the liquid in the clearwell was pumped directly to Manhole-175. At the BSL, the runoff mixes with process wastewater and the combined liquid effluent is treated in the Biodenitrification Facility (BDN) to reduce nitrates. The combined treated effluent is pumped to Manhole-175 and flows through a buried pipeline to the Great Miami River.

The second source of effluent is ***sanitary sewage***, which is processed at the Sewage Treatment Plant to remove biological contaminants. This effluent is sent to Manhole-175 and on to the Great Miami River.

The third source of liquid effluent is ***controlled stormwater runoff.*** This effluent is produced from rain falling in the area shown in Figure 25.

(Text continues on page 87.)

FIGURE 23: Great Miami River, Paddy's Run, FMPC Outfall Ditch, and Effluent Line



LEGEND

FMPC Site

Plant Perimeter

Production Area Perimeter

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FIGURE 24: FMPC Liquid Effluent Flow Diagram

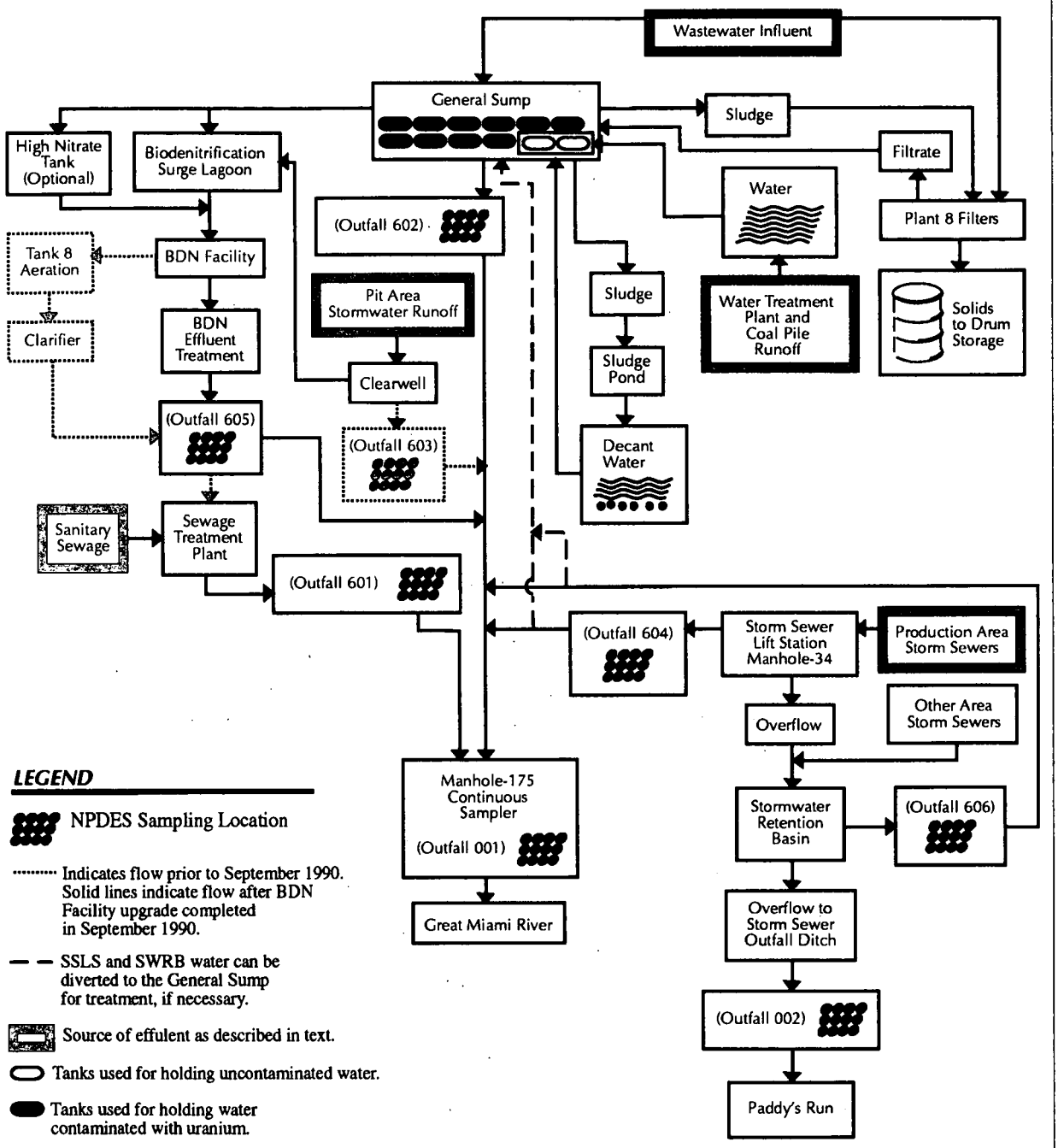
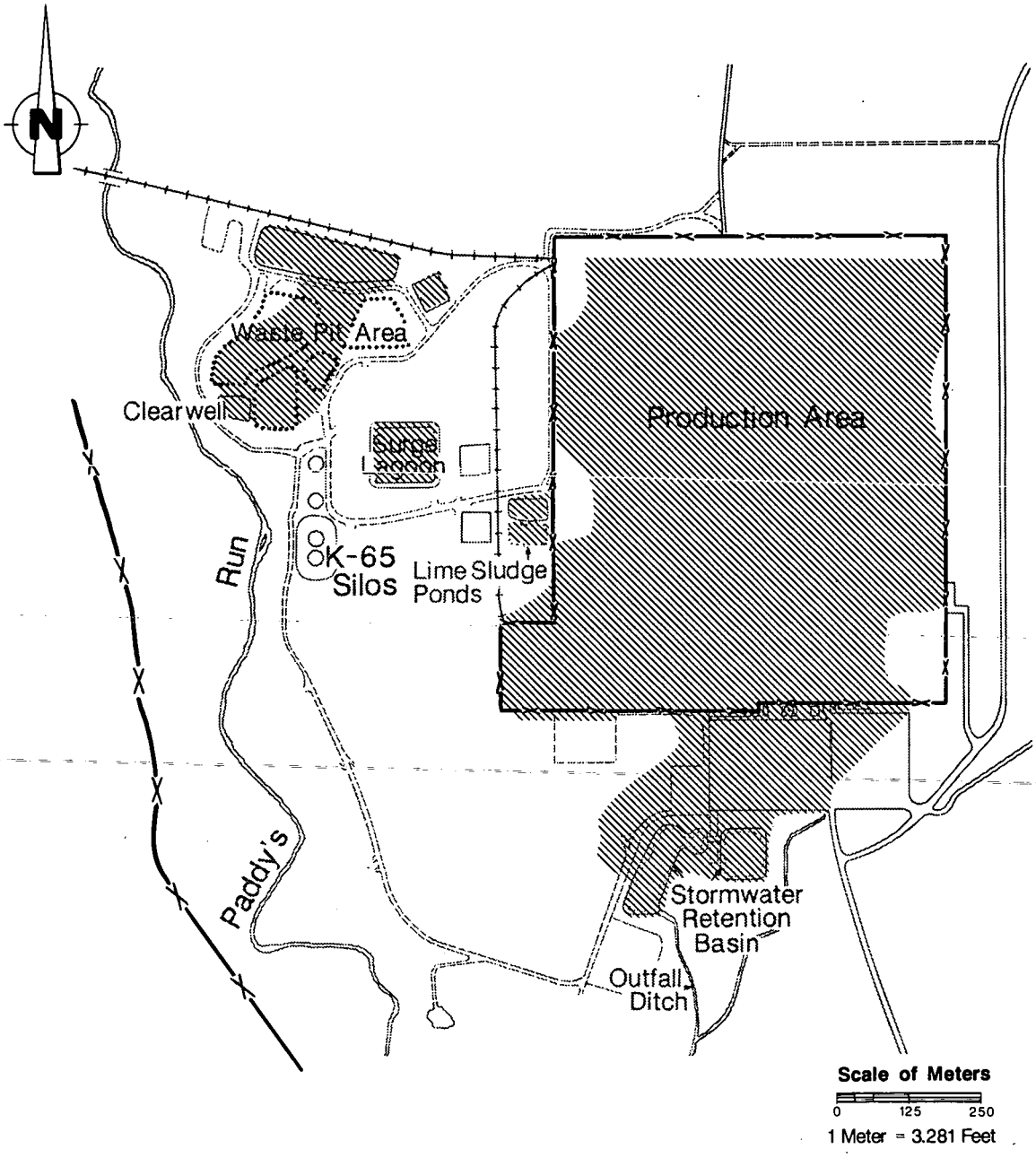


FIGURE 25: Area of Controlled Stormwater Runoff



LEGEND

Shaded Areas are Collected and Eventually Discharged to the Great Miami River

Plant Perimeter

Production Area Perimeter

1302

While some contaminated stormwater is uncontrolled and runs directly offsite, stormwater which contains the major quantities of uranium and other pollutants is collected in this system.

Stormwater runoff from the production area is collected by a network of storm sewers that converge at Manhole-34. A small dam at Manhole-34 allows the collected water to be diverted to the Storm Sewer Lift Station (SSLS) during dry weather. The SSLS is pumped to Manhole-175 and then to the Great Miami River.

When it rains, the SSLS temporarily shuts down. On such occasions, the runoff bypasses the SSLS and flows by gravity to the Stormwater Retention Basin (SWRB) along with water collected downstream of Manhole-34. The solids settle for a minimum of 24 hours, and the process of pumping the clarified stormwater runoff from the SWRB to Manhole-175 begins. This process continues for several days, depending on the amount of water in the SWRB.

The fourth source of liquid effluent is ***wastewater from the water treatment plant and runoff from the coal pile***. At the water treatment plant, groundwater undergoes treatment typical for such water supplies. The effluent from the treatment plant is sent to the General Sump. (The General Sump is the common name for a series of tanks that are used for settling solids present in the liquid effluents.) At the General Sump, solids partially separate from the liquid. The liquid is sent to Manhole-175, and the sludge (solids) is sent to the sludge pond where settling continues for several days. The clarified liquid effluent from the sludge pond is returned to the General Sump and is also discharged to Manhole-175. Stormwater runoff from the coal pile, after collecting and settling in a holding pond, is also sent to the General Sump and handled in a similar manner.

The wells that supply water for drinking at the FMPC are located in the lower sand and gravel aquifer. The water is treated not to remove uranium — concentrations are at background levels — but to remove minerals and "soften" the water.

In summary, the FMPC controls liquid effluents, including process wastewater, sanitary sewage, some stormwater runoff, and wastewater from the water treatment plant — all of which eventually enter Manhole-175. There, the effluents combine and mix to form a single liquid from which a representative sample can be taken before the effluent flows to the Great Miami River.

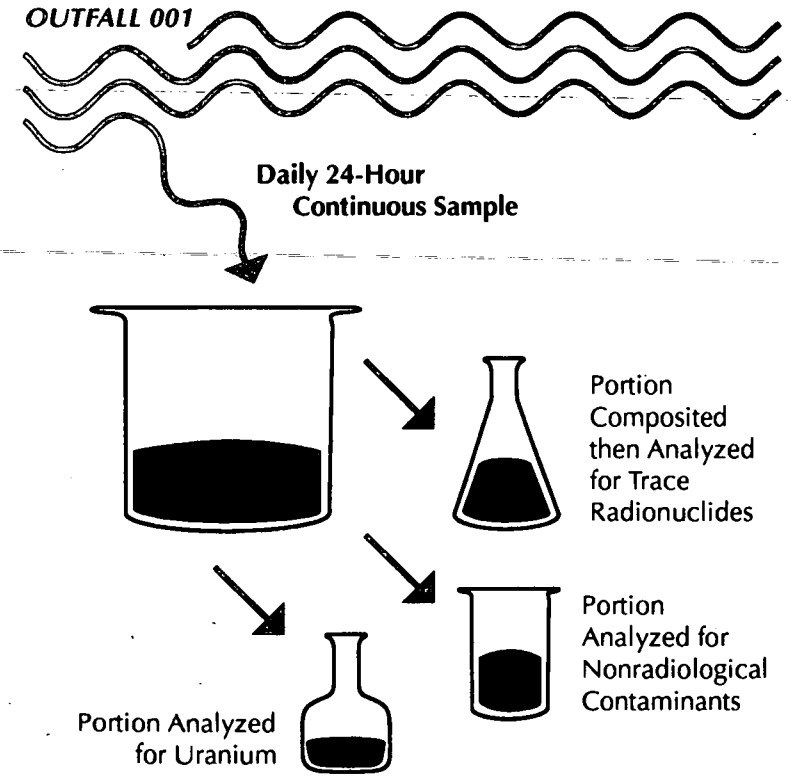
On an average day during 1990, 3,743,000,000 gallons of Great Miami River water flowed past the FMPC effluent line.[8] The FMPC discharged an average of 730,000 gallons of effluent into the river each day. Therefore, on average, each gallon of effluent discharged was diluted by about 5,000 gallons of river water.

Sampling Methodologies

The mixed effluent, described above, is sampled at Manhole-175 by a flow-proportional sampler, a continuously operating device which removes a varying amount of the effluent in proportion to the volume of flow to the river. After every 24 hours of operation, the collected liquid is removed from the automatic sampler to provide a daily flow-weighted sample of the effluent (Figure 26).

A portion of each daily sample of effluent flowing through Manhole-175 was analyzed to determine the amount of total uranium discharged to the Great Miami River. In addition, portions of all daily samples collected during each month were mixed to form either monthly composites, or, as with cesium-137, ruthenium-106, and strontium-90, three-month composites. The monthly composites were analyzed for the four uranium isotopes and 13 other radionuclides listed in Table 7. Composites, rather than daily samples, were analyzed because many of the radionuclides were present in only trace amounts, and it would be neither practical nor cost-effective to perform more frequent analyses for them.

FIGURE 26: Continuous Sampling at Outfall 001



Results of Laboratory Analyses

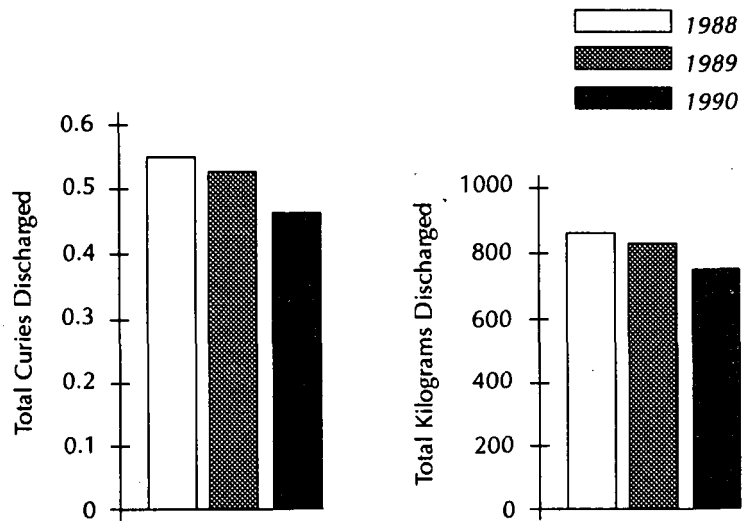
Table 7 is a summary of the radionuclide analysis of the liquid effluent to the Great Miami River. The table includes the 1990 average concentration (in pCi/L) of each radionuclide, and the total Curies discharged during 1990 and 1989. The average concentration of each radionuclide is compared to its Derived Concentration Guideline.

During 1990, 0.46 Curies (786 kg or 1,733 pounds) of uranium was discharged to the Great Miami River at Manhole-175. This was a decrease of 11.5% on an activity basis and 6.5% on a mass basis, in comparison to the 0.52 Curies (841 kg or 1,854 pounds) of uranium dis-

charged to the river during 1989. Comparisons of uranium discharges at Manhole-175 during 1990 and the two previous years are shown in Figure 27 (in Curies and kilograms).

Since DOE orders state that a dose must be estimated based on all the radionuclides present in the effluent, a site such as the FMPC cannot simply compare the concentration of each radionuclide in its effluent to the individual DCGs to determine if the combined effluent is within DOE guidelines. The percentages of the DCGs for all radionuclides must be added.[13] Using the information in Table 7 as an example, the total percent of DCGs for the four uranium isotopes equals 85. The concentration of radium-228 is less than 10.6% of its DCG, actinium-227 is less than 10%, and so on. The total for all DCGs is less than 150%. (The total is "less than" because the majority of radionuclide concentrations were below analysis detection levels.) However, since the total is above 100, the FMPC is required to use the Best Available Technology to reduce radionuclide concentrations in its effluent. To accomplish this, the FMPC is designing an Advanced Wastewater Treatment Facility.

FIGURE 27: Total Uranium (in Curies and Kilograms) Discharged through Outfall 001, 1988 to 1990



Other than the uranium isotopes and thorium-230 and -234, strontium-90 was the only radionuclide detected in the effluent in 1990. As was the case in 1989, the thorium-234 maximum concentration is calculated based on its being in radioactive decay equilibrium with uranium-238. The average concentration of strontium-90 was only 0.04% of its DCG. Of the 13 other radionuclides listed in Table 7, the average concentrations of five were less than 1% of their respective DCGs, and seven of the remaining eight were less than 11%, while lead-210 may have been greater than 11%.

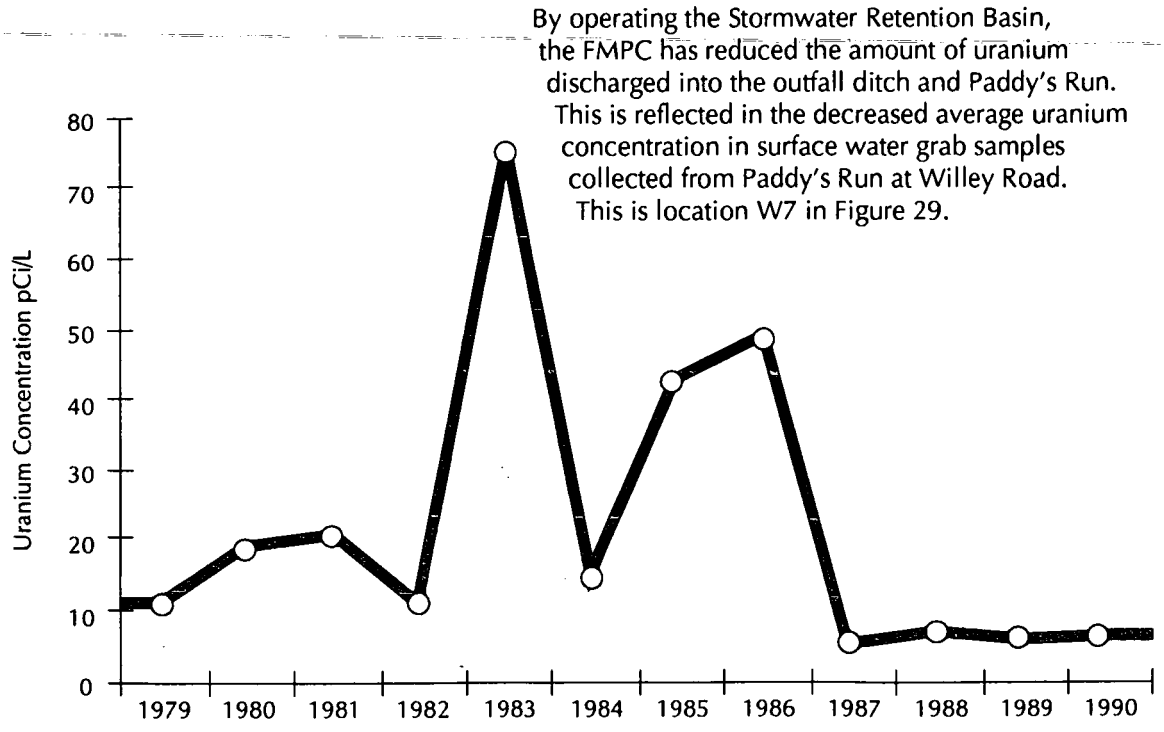
The average percent of DCG for lead-210 is listed in Table 7 as less than 28.2%. However, the offsite laboratory's detection limit for lead-210 changed significantly during 1990. The detection limit for January through April was 20 pCi/L, while for May through December it dropped to 3.0 pCi/L. In fact, the concentrations for the September, November, and December composites were only slightly above the new detection

limit (3.5 pCi/L was the maximum value). If the detection limit had been 3 pCi/L for the entire year, the percent DCG for lead-210 may have been less than 10%.

The FMPC also monitors any discharges to Paddy's Run that occur from the overflow of the Stormwater Retention Basin. During one period of unusually heavy rainfall in May 1990, all the stormwater runoff that entered the SWRB could not be pumped to Manhole-175 for discharge to the river. As a result, 610,000 gallons of stormwater containing 1.2 kg (2.6 pounds) of uranium overflowed the SWRB and was discharged into the outfall ditch. Since the SWRB began operating in 1986, the amount of uranium entering the outfall ditch has been substantially reduced (Figure 28).

In March 1990, the FMPC began reporting a general estimate of uranium in uncontrolled stormwater runoff to Paddy's Run to USEPA. Based on a series of grab samples collected in various onsite drainage ditches that flow into Paddy's Run, the FMPC developed a general estimate of 4.5 kg (10 pounds) of uranium in the runoff to Paddy's Run for every inch of rain. For the March through December 1990 period, the general estimate

FIGURE 28: Average Uranium Concentration at Willey Road



of uranium in stormwater runoff to Paddy's Run was reported as 193 kg (425 pounds). The FMPC is increasing the area of controlled stormwater runoff, as described in Chapter Ten under Operable Unit 1.

In addition to monitoring its liquid effluent, the FMPC examines both the Great Miami River and Paddy's Run surface water for possible effects from FMPC operations.

Surface Water Sampling for Radionuclides

FMPC surface water sampling measures the effects of two sources of contamination: the discharge of liquid effluents into the Great Miami River and the effects of uncontrolled stormwater runoff into Paddy's Run.

As mentioned earlier, the liquid effluent to the river includes process wastewater, sanitary sewage, controlled stormwater runoff, and wastewater runoff from the water treatment plant and coal pile. There are two routes by which liquids from the FMPC can enter Paddy's Run — the first route is through the overflow of the Stormwater Retention Basin, and the second route is through uncontrolled stormwater runoff. (Figure 25 shows the area of controlled stormwater runoff.)

Sampling Methodologies

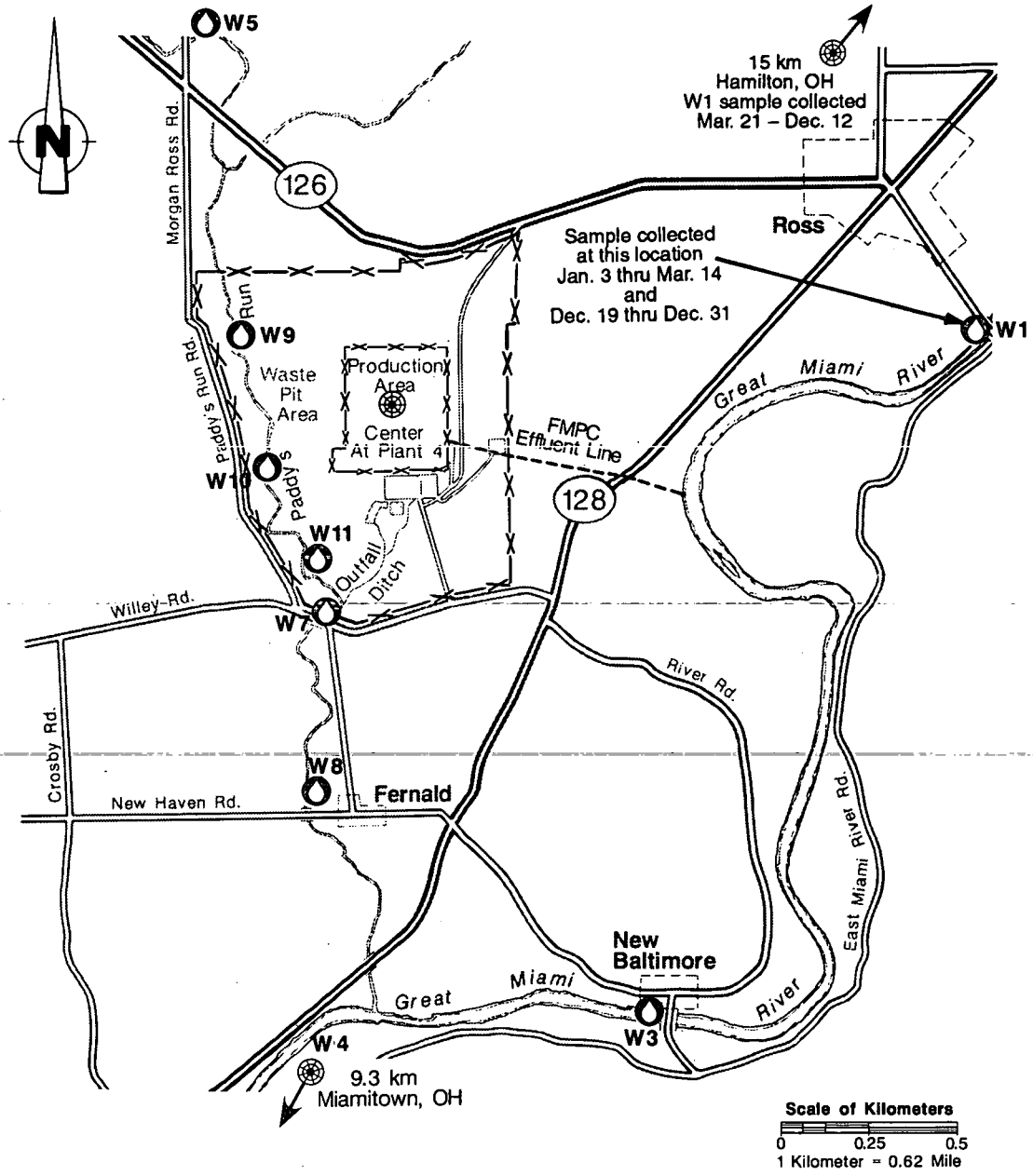
During 1990, surface water was sampled at the following locations identified in Figure 29:

- Three locations along the Great Miami River (W1 — upstream from the effluent discharge, W3, and W4),
- Three onsite locations along Paddy's Run (W9, W10, and W11), and
- Three offsite locations along Paddy's Run (W5 — upstream from the site, W7, and W8).

Each week, one of the daily samples from each river sampling location was analyzed for total uranium. Portions of the daily W1 and W3 samples and the weekly W4 samples were combined to form a monthly composite for each location, which was then analyzed for radium-226 and radium-228. Six-month composites, prepared from the individual monthly composites, were analyzed for cesium-137, strontium-90, and technetium-99.

Weekly grab samples were collected at six locations along Paddy's Run and analyzed for total uranium. Locations W10, W11, and W7 were occasionally dry and could not be sampled. In addition, two-month composites of weekly samples from W5 were analyzed for isotopic

FIGURE 29: Surface Water Sampling Locations



LEGEND

- Sampling Location
- Distance from Center of Production Area to Sampling Locations off Map
- Plant Perimeter
- Production Area Perimeter

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radium, as were monthly composites at W7 (or W8 if there was not enough sample from W7). During 1990, nine isotopic radium analyses were completed for W7 and three for W8.

Results of Laboratory Analyses

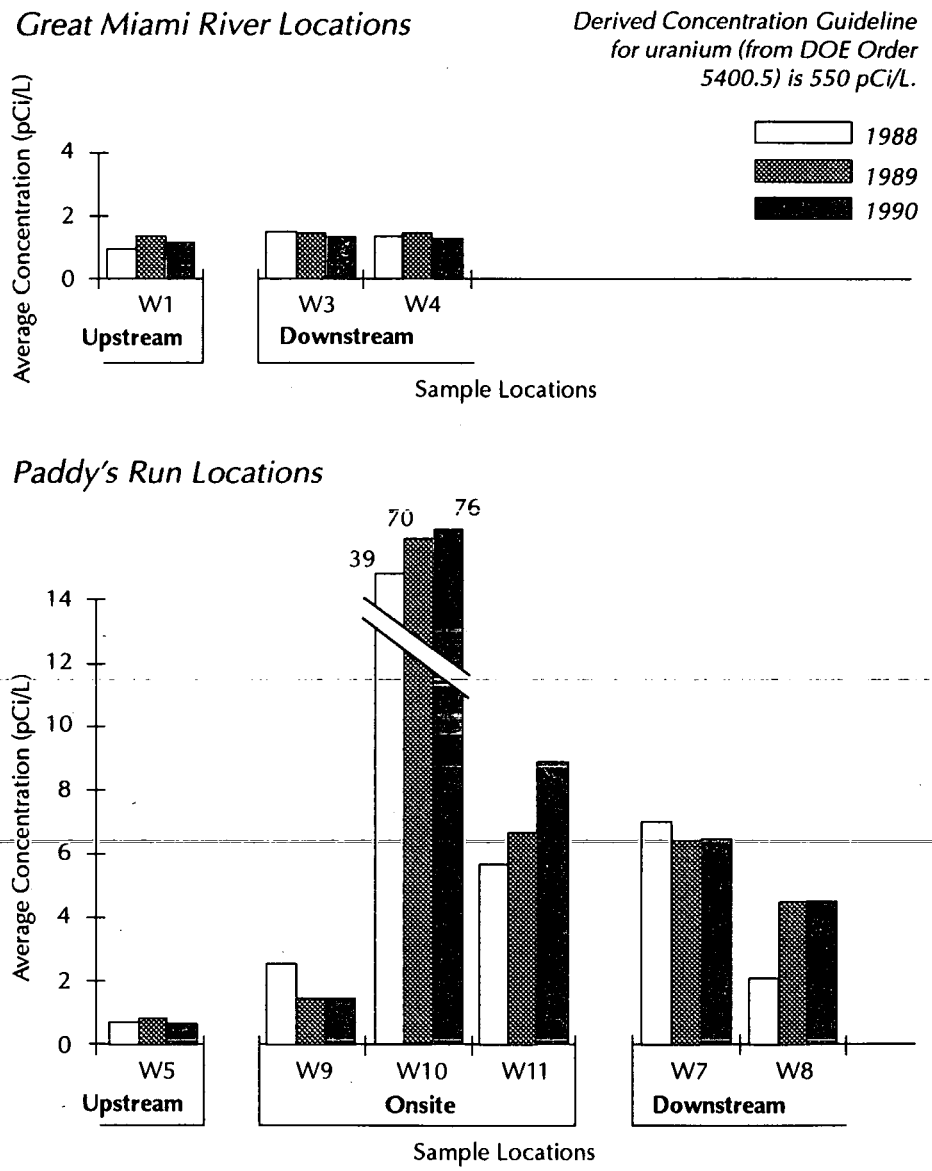
The radionuclide concentrations found in surface water samples collected during 1990 are summarized in Table 8. These data indicate that the average uranium concentration in the Great Miami River was slightly higher at sampling locations W3 and W4, both downstream of the FMPC outfall, than at the W1 upstream location. To more closely estimate the amount of increase in the downstream Great Miami River uranium concentration, the FMPC performed a statistical evaluation of the individual weekly uranium results for the three river sampling locations. An increase of 0.14 pCi/L was estimated from this evaluation.[28] This is equivalent to a 12% increase in the 1.2 pCi/L background uranium concentration found at the W1 upstream location.

The increase in the river uranium concentration was also calculated using the 1990 values for the total amount of uranium discharged at Outfall 001 (0.46 Curies, Table 7) and the estimated total annual river flow (5.17×10^{12} liters or 137,000,000,000 gallons). The calculated increase was 0.089 pCi/L which is in reasonable agreement with the increase estimated from the statistical evaluation of the uranium results of weekly river samples.

There were no measurable differences in the concentrations of radium-226, radium-228, cesium-137, and technetium-99 found in upstream and downstream Great Miami River samples collected during 1990. For strontium-90, there was a slight increase in concentration at W3, but its concentration was lower at W4 (farther downriver) than at W1 (the upstream location). Even the maximum concentration of strontium-90 was only 0.16% of the DCG. As shown in Table 7, the concentrations of these radionuclides in the liquid effluent discharged to the river were very low and would result in very little, if any, increase in the concentrations already present in the river.

The FMPC analyzed surface water samples collected from Paddy's Run at upstream sampling point W5 to determine concentrations of uranium and radium normally present in this stream. The average uranium concentration at W5 was 0.75 pCi/L. Higher average uranium concentrations were found at the downstream sampling points (Figure 30). However, average uranium concentrations at all Paddy's Run monitoring locations were well within DOE guidelines, ranging from 0.27% of the DCG at W9 to 14% at W10. Downstream radium concentrations for Paddy's Run were similar or lower than concentrations found at W5.

FIGURE 30: Average Uranium Concentrations in Surface Water, 1988 to 1990



1990 results from W10 show a notable increase in average uranium concentrations over 1989. The high average value was the result of several very high weekly results (maximum concentration during 1990 was 1,100 pCi/L; the median concentration for this location was 5.7 pCi/L). The occasional high concentrations may be attributable to the movement of soil in the waste pit area. As soil is disturbed during the construction of environmental improvement projects, stormwater runoff flowing into Paddy's Run upstream of W10 may be carrying more solids,

including uranium, than in past years. In addition, a drainage ditch originating near the Pilot Plant flows into Paddy's Run at this location. To determine if the ditch contained elevated uranium concentrations which could be affecting analytical data at W10, the FMPC added sampling locations in 1991 just upstream of W10 (above the influence of the drainage ditch), and a second location about 200 meters (650 feet) downstream of W10 where more complete mixing of the drainage ditch and Paddy's Run flows would have taken place. These additional data will be reported in the 1991 AER.

Sediment Sampling for Radionuclides

Contaminants present in surface water could settle, or precipitate, and thereby accumulate in sediment. Thus, sampling and analysis of sediments provide a way to evaluate possible cumulative effects of routine discharges of treated effluents into the Great Miami River and the effects of stormwater runoff into Paddy's Run.

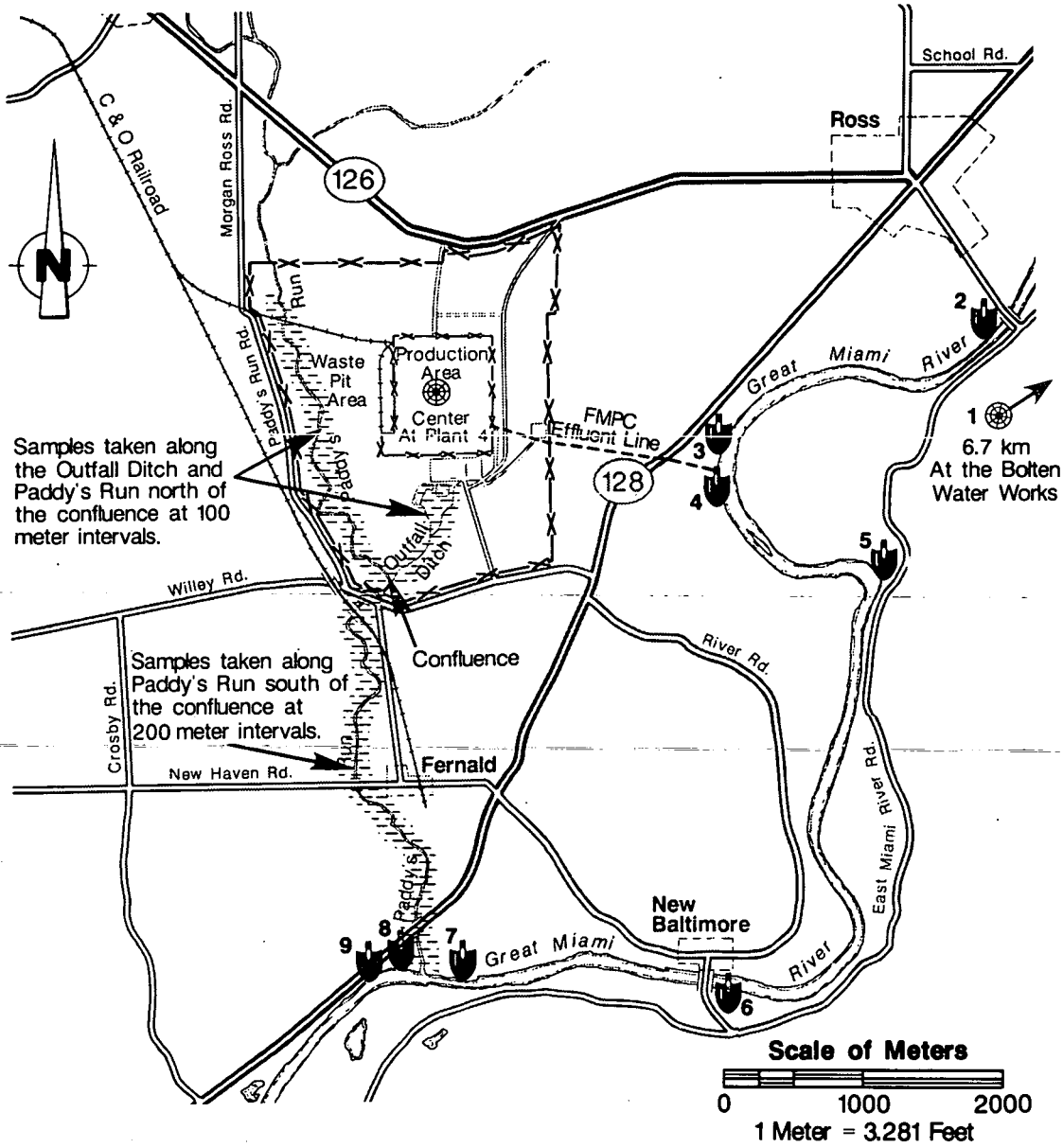
The FMPC collected sediment samples at nine locations along the Great Miami River from both upstream and downstream of the FMPC outfall, and at 100-meter and 200-meter intervals along Paddy's Run and the Storm Sewer Outfall Ditch (Figure 31). Three separate samples were collected at each location in Paddy's Run and the outfall ditch — one from each bank and one from the center of the stream bed. Seventy samples were taken at 25 locations (five sampling locations were all rock or had deep, standing water) along Paddy's Run upstream of the confluence with the outfall ditch; 54 samples were taken at 18 locations along Paddy's Run downstream of the confluence; and 21 samples were taken from seven locations along the outfall ditch.

All sediment samples were analyzed for technetium-99 and isotopes of uranium, thorium, radium, and plutonium. There are currently no DOE or USEPA guidelines or standards for uranium or other radionuclides in sediment.

The data in Table 9 show there were no significant differences in the concentration of uranium and other radionuclides found in sediment samples collected from the Great Miami River upstream and downstream of the FMPC effluent discharge line. Therefore, FMPC liquid effluent discharges did not cause any discernible increase in the background levels of radionuclides in Great Miami River sediment.

While uranium concentrations in sediment at some individual locations in Paddy's Run were above the background range for soils in Ohio, the average concentration of uranium was within background range. These data were compared to data from previous years at the same locations,

FIGURE 31: Sediment Sampling Locations



LEGEND

- Single Sampling Location
- Distance from Center of Production Area to Sampling Locations off Map
- Cross Section Sampling Location
- Plant Perimeter
- Production Area Perimeter

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and no trends were observed. The average uranium concentration in the outfall ditch (4.8 pCi/g) was slightly above background levels. Uranium concentrations in individual locations along this ditch have been elevated in previous years as well, probably because of stormwater runoff from onsite flowing into the outfall ditch over the years.

Fish Sampling for Uranium

Another component of the liquid pathway is fish in the Great Miami River. The FMPC, with the help of a research team from the University of Cincinnati, has been sampling fish in the river for the last several years. The team collected fish by electrofishing, one of the more efficient methods of collecting fish samples unbiased with respect to size and species. No unusual results were found for 1990, and uranium concentrations were normal.

In October and November 1990, the team collected 295 fish from five stations along the river (Figure 32):

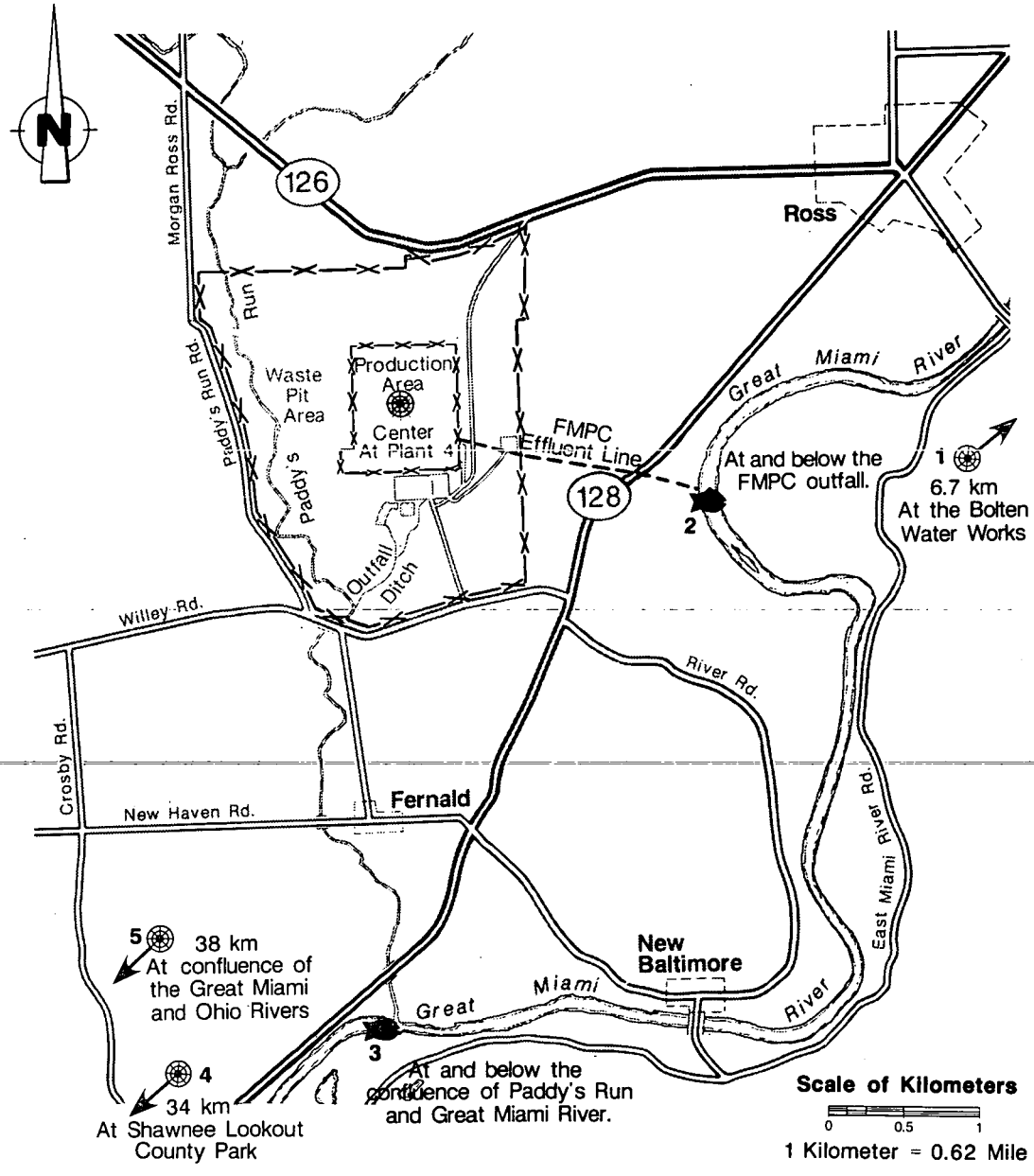
- **River mile 28** – upstream from the FMPC at the Bolton Water Works,
- **River mile 24** – at the FMPC effluent discharge,
- **River mile 19** – where Paddy's Run empties into the river,
- **River mile 1.2** – in a slow-moving backwater, and
- **River mile 0.0** – at the mouth of the Great Miami River.

These collections were made more than a month later than in years past, and included two new stations (river miles 1.2 and 0.0). The variety of fish species collected included gizzard shad, large mouth bass, white bass, striped bass, river carpsucker, quillback carp, drum, long nose gar, large mouth buffalo, sauger, carp, black buffalo, and channel catfish.

Analyses of the general fish population focused on changes in species composition, fish size, and growth rates. Statistical examination of results from the five stations was performed to determine if differences by station reflected changes in natural habitat or levels of pollution. Previous years' results were compared to determine if 1990 results reflected seasonal differences caused by a later sampling date or different levels of pollution. However, both examinations concluded that Great Miami River fish were not affected by FMPC discharges in 1990, as the fish sampled appeared to be in general good health and growing at a normal rate.[29]

The average uranium concentration reported in fish from all five sampling locations was consistent with results reported for 1989 (Table 10). Statistical analyses were performed to determine if uranium concentrations were significantly higher at one particular sampling location or for

FIGURE 32: Fish Sampling Locations



LEGEND

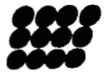
- Sampling Location
- Distance from Center of Production Area to Sampling Locations off Map
- Plant Perimeter
- Production Area Perimeter

1302

one particular family type. Results showed that correlations between concentrations and both location and family were statistically insignificant. In fact, the upstream sampling location had the second highest average uranium concentration, and it can be concluded that FMPC operations had no significant impact on uranium concentration in fish.[30] An estimated dose from eating fish caught in the Great Miami River at the FMPC outfall is discussed in Chapter Seven.

Monitoring for Nonradioactive Pollutants

This second section of the chapter looks at concentrations of nonradioactive pollutants in the FMPC's liquid effluent, the Great Miami River, and Paddy's Run. The discharge of nonradioactive pollutants in liquid effluent is controlled to meet the requirements of the site's National Pollutant Discharge Elimination System (NPDES) permit. Criteria used for nonradioactive contaminants in the river and creek are taken from standards adopted by the OEPA. Although no surface water downstream from the FMPC is designated as a source of drinking water, concentrations of nonradioactive pollutants in the river are compared to drinking water standards as a means of evaluating any possible effects from FMPC operations.



NPDES Compliance Summary for 1990

The NPDES permitting process for the FMPC is under the jurisdiction of the State of Ohio to control the discharge of nonradioactive pollutants to Ohio waters. The permit specifies sampling locations, sampling and reporting schedules, discharge limits, water quality standards, and other restrictions on FMPC effluents discharged to the Great Miami River and Paddy's Run. The FMPC met the NPDES daily maximum and monthly average permit limits more than 99% of the time during 1990 (Tables 11A and 11B). The percentage of compliance is shown in Figure 33.

January and February 1990 were the last two months that the FMPC operated under the previous NPDES permit. That permit specified seven regulated monitoring points — two locations were direct discharges to Ohio waters (Outfalls 001 and 002) and five were internal contributing effluent streams. These discharges were sampled at the frequencies shown in Table 11A, and the analytical results were reported monthly to the OEPA.

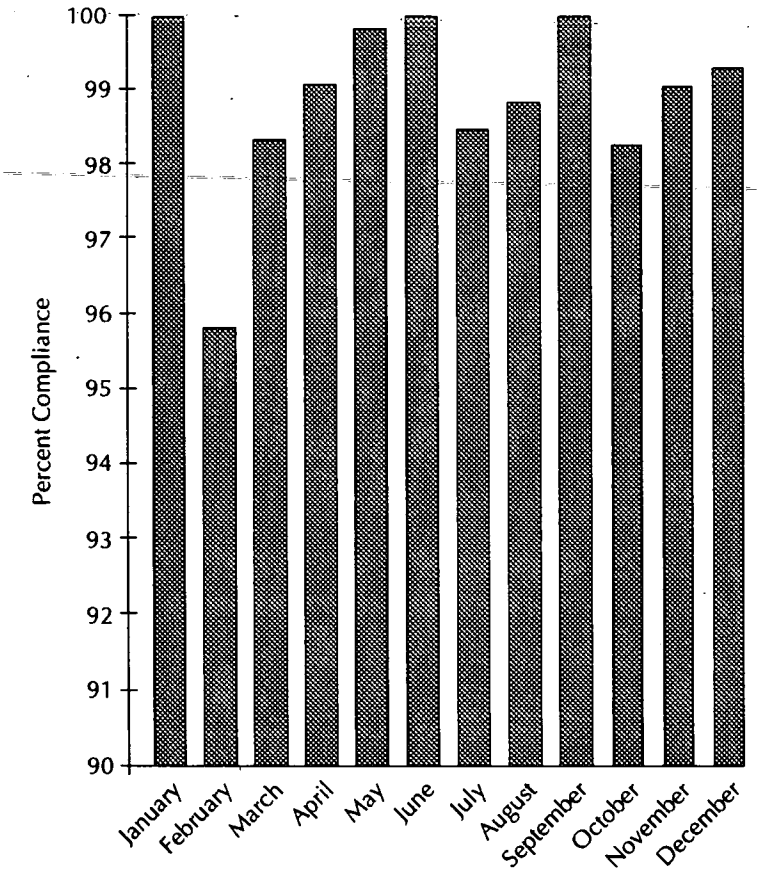
Ohio EPA renewed the site's NPDES Permit on February 12, 1990, and the revised monitoring requirements took effect in March 1990. The new permit significantly increased monitoring requirements compared to the previous permit. For example, the new permit added the following:

- Continuous monitoring and discharge limits for pH at several outfalls,
- Discharge limits for several new constituents, such as fluoride and various metals, and
- A requirement for monitoring the discharge of stormwater collected in the Stormwater Retention Basin.

In September 1990, changes in the process flow enabled the FMPC to eliminate the direct discharge from the clearwell to Manhole-175. The clearwell effluent now mixes with other effluents at the BSL, and is eventually monitored for NPDES parameters at the BDN. The outfall locations are identified in Figure 24.

The total of 50 noncompliances for the year was significantly higher than the number for 1989. It should be recognized however, that due to the increased requirements of the new permit, the total number of analyses during 1990 more than tripled compared to 1989. Of the 5,137 analyses, 5,087 were within the limits of the permit.

FIGURE 33: NPDES Compliance, 1990



The 50 noncompliances during 1990 occurred primarily for two constituents: 28 for pH and 11 for fluoride. Twenty of the pH noncompliances occurred at the discharge to the Great Miami River; the other eight occurred at internal monitoring points. The primary cause of these noncompliances is believed to have been problems calibrating the instruments needed for continuous monitoring of pH, which is required by the renewed NPDES permit. The instruments periodically drifted out of calibration causing a reading above the maximum permit limit of 9.0. In most cases, grab samples taken at the same time indicated that the actual pH was within the permit limits. However, the readings were reported to OEPA as noncompliances as specified in the permit. The FMPC has

greatly reduced the number of pH noncompliances by increasing the inspection frequency of the monitoring equipment.

Eight of the fluoride noncompliances during 1990 occurred at the BDN (Outfall 605) after it was restarted in September. The purpose of the fluoride limit at the BDN is to demonstrate that the FMPC is using the Best Available Technology for fluoride removal. In response to the noncompliances, the FMPC began a program of sampling and laboratory studies to evaluate sources of fluoride, and to determine the effectiveness of BAT treatment in providing the removal needed to meet the 1.3 mg/L monthly average limit. The results will be the basis for determining the most effective means of meeting the intent of the NPDES permit.

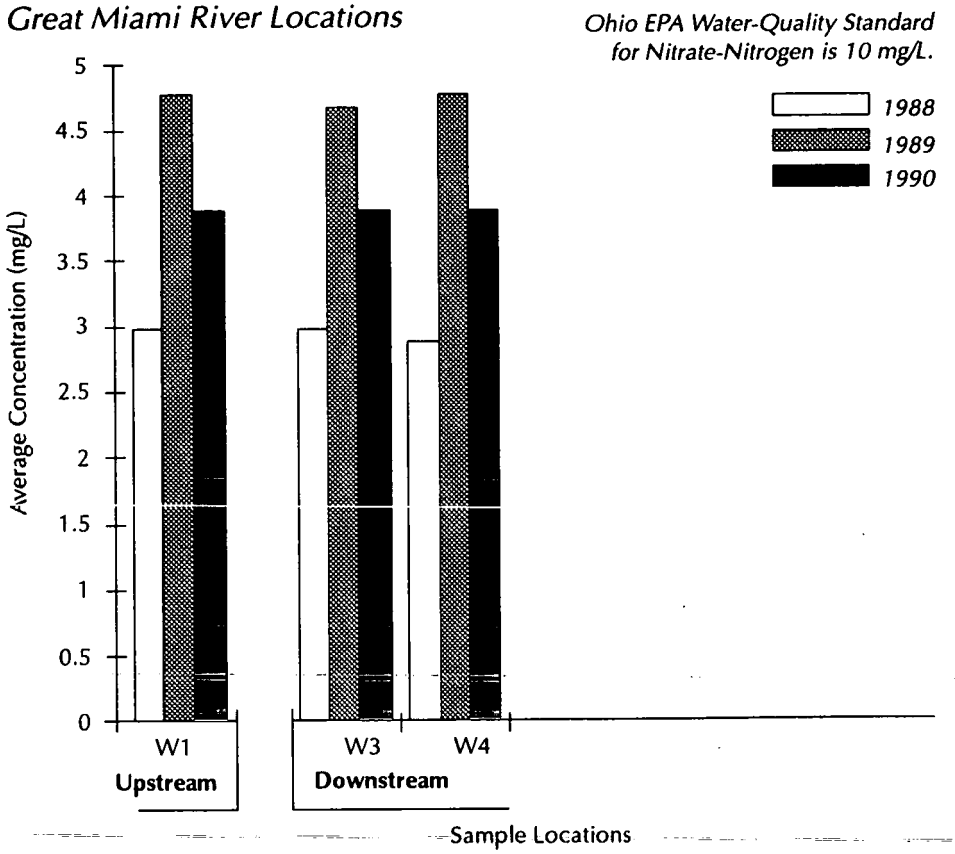
Surface Water Sampling for Water-Quality Indicators

During 1990, the FMPC analyzed weekly surface water samples from the river and Paddy's Run for fluoride, nitrate-nitrogen, chloride, and pH.

The 1990 data, presented in Tables 12 and 13 and Figures 34 and 35, indicate that operations at the FMPC had minimal affect, if any, on nitrate-nitrogen and chloride concentrations or pH in the Great Miami River or Paddy's Run. The average concentrations of these anions and pH were all within OEPA standards for water designated for public use. (These standards do not apply to FMPC discharges because OEPA has not designated either Paddy's Run or the Great Miami River as public water supplies south of the FMPC.) Average concentrations for these anions were the same or only slightly higher south of the site than they were at the upstream locations.

All average fluoride concentrations were within OEPA standards for a public water supply; however, one sample taken at W7 was above this standard. This sample, collected during September, was 2.5 mg/L. Increases in fluoride concentrations in Paddy's Run (compared to the upstream location W5) may be from stormwater runoff from the site since fluoride had been used in the production process, and the waste pits contain magnesium fluoride. Fluoride analysis of surface water from the river and Paddy's Run will continue during 1991.

FIGURE 34: Average Nitrate-Nitrogen Concentrations in Surface Water, 1988 to 1990



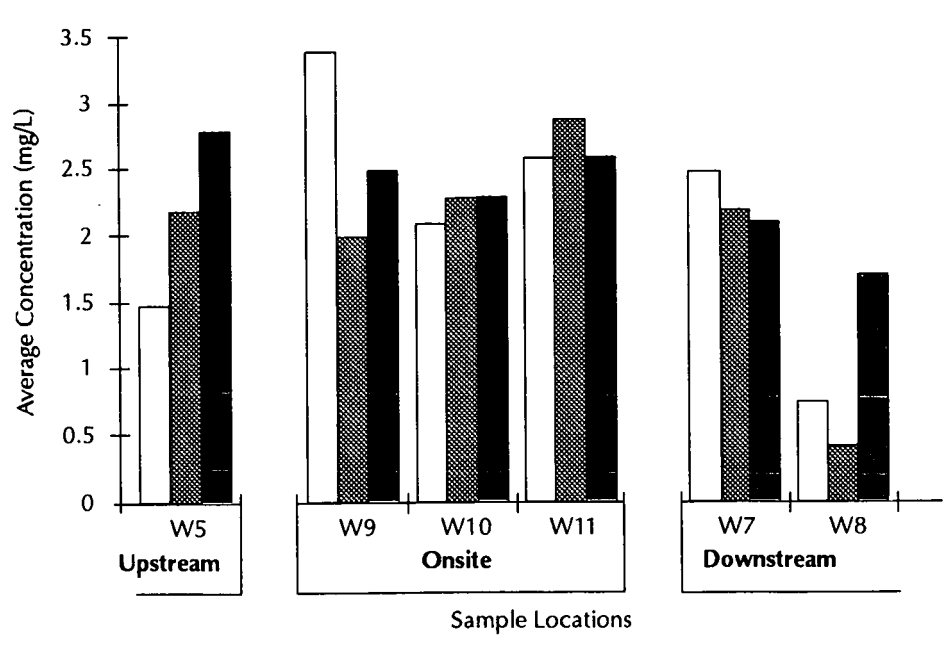
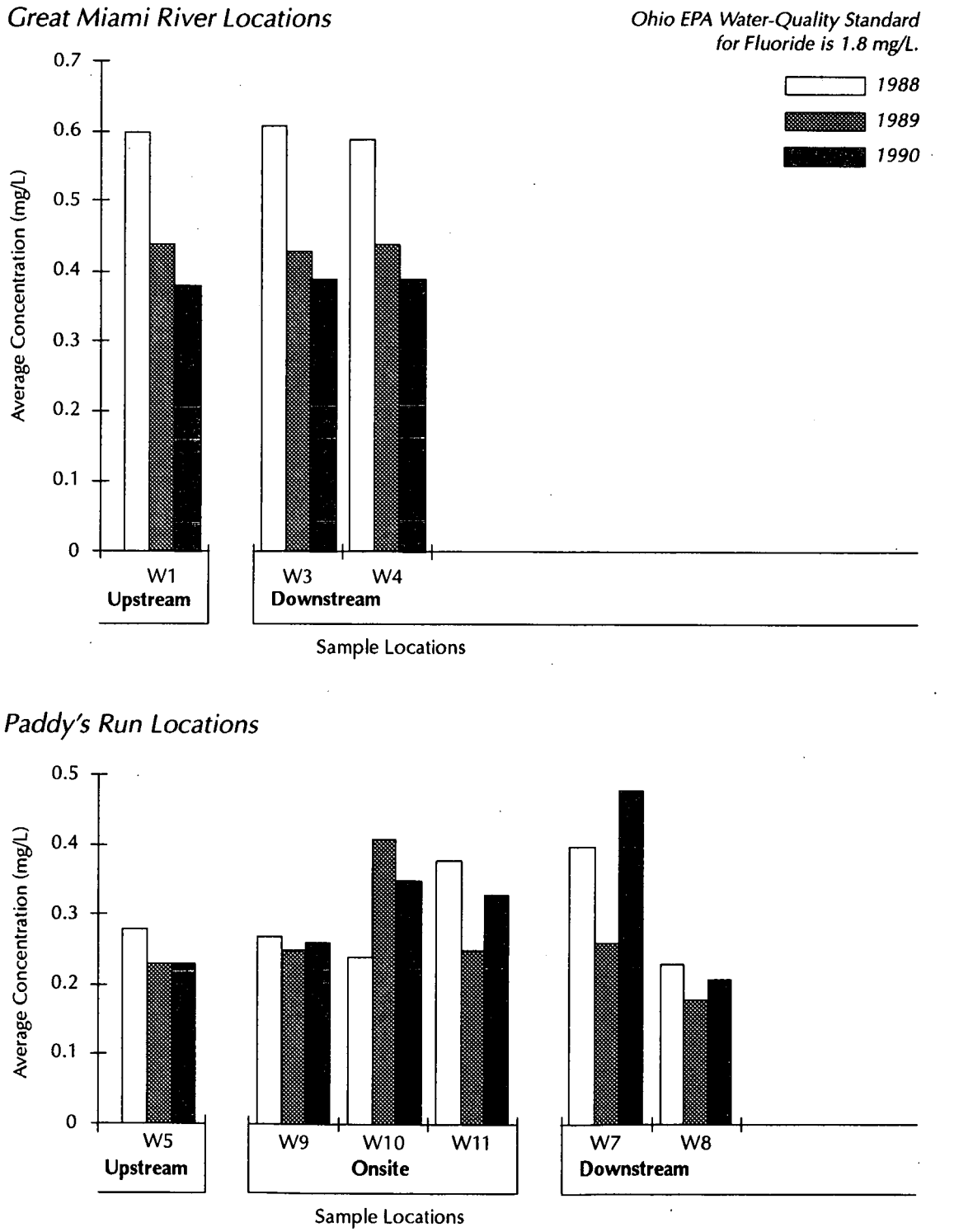


FIGURE 35: Average Fluoride Concentrations in Surface Water, 1988 to 1990



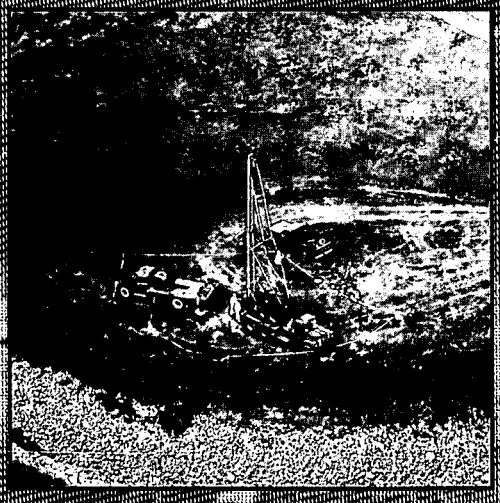
SUMMARY OF LIQUID PATHWAY: EFFLUENT AND SURFACE WATER MONITORING RESULTS

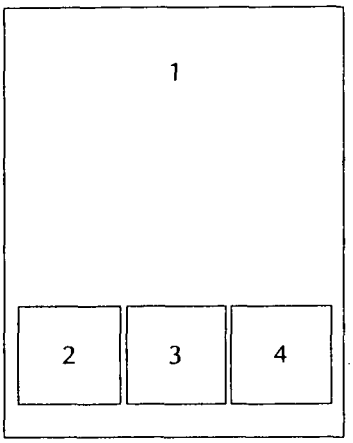
The FMPC extensively monitors its liquid effluent and the local surface water systems to detect and track the movement of contaminants that can originate from the site. The quantities of individual radionuclides discharged to the Great Miami River were within DOE guidelines. However, the sum of the percent of guideline for each radionuclide discharged to the river was greater than 100%, thus exceeding the discharge guidelines. The FMPC is designing an Advanced Wastewater Treatment Facility which will reduce the amount of both radioactive and nonradioactive discharges to the river. The FMPC complied with the NPDES requirements for nonradioactive contaminants more than 99% of the time during 1990. Surface water sampling results indicated that uranium concentrations in Paddy's Run were higher than the upstream location, especially near the K-65 Silos. A project is underway to reduce uncontrolled stormwater runoff to Paddy's Run from the waste pit area which will decrease the amount of uranium and other contaminants entering this stream.

By controlling the concentration of radionuclides in the effluent, and by reducing the amount of stormwater runoff to Paddy's Run, the FMPC can lessen its impact on the various components of the liquid pathway. In particular, surface water runoff can enter the aquifer and influence groundwater quality. The next chapter looks at the groundwater component of the liquid pathway.

2800

CHAPTER 6





1 – The Great Miami Aquifer is a source of water for homes, farms, and businesses.

2 – One method of collecting groundwater samples is by lowering a teflon baler into monitoring wells.

3 – As the groundwater monitoring program expands, new wells continue to be drilled.

4 – During groundwater sampling, field tests are done for pH, specific conductivity, temperature, and other water-quality indicators.

CHAPTER SIX

Liquid Pathway: Groundwater Monitoring Results

This section continues the discussion of the liquid pathway, as surface water runoff and leaching through the soil may contaminate the groundwater. The FMPC carefully monitors the groundwater under and in the vicinity of the site to identify and track the movement of pollutants which may be present in the Great Miami Aquifer. By drilling wells, scientists can analyze the groundwater and also learn much about the soil and its ability to restrict the movement of contaminants into the groundwater. This enables the FMPC to better define the steps the site should take to control present contamination and to prevent additional contamination from occurring.

Results in Brief: 1990 Liquid Pathway: Groundwater

1990 results reflect the reorganization of FMPC groundwater sampling efforts into a comprehensive sampling program, while private well sampling continued as a service to the local community.

Private Wells – Uranium concentrations were consistent with 1989 results, and only three wells (not used for drinking water) showed uranium concentrations above the 22 pCi/L DOE guideline. Iron and manganese were detected above the secondary drinking water standards in several wells, but these natural elements of groundwater are commonly found in similar concentrations in this part of the state.

Comprehensive Sampling – Uranium, thorium, radium, strontium, and technetium were detected above the DOE guidelines; areas of concern, particularly the South Plume, continue to be monitored. Arsenic, cadmium, nitrates, and VOCs have been detected above the drinking water maximum contaminant levels and have indicated areas of possible hazardous waste contamination.

History of Groundwater Monitoring at the FMPC

Several groundwater monitoring programs have been evolving throughout the history of the site. The three production wells that supply drinking water to the plant were among the first drilled during the construction of the site in 1951. From 1959 to 1965, 11 monitoring wells were installed in the waste pit area to see if pit operations were affecting the groundwater. Since then, three of the 10 monitoring wells have been deepened and three others capped as more waste pits were built. Two wells were added in 1982. These remaining 13 wells, including the three production wells, were the focal point for the Environmental Monitoring Program through 1989. (In this AER, they are summarized for the last time as a separate group of wells in Appendix B.)

In late 1981, the State of Ohio sampled three wells south of the site and found elevated levels of beta activity. The FMPC then sampled these wells and found that this activity was due to potassium-40, which is not present in FMPC materials. However, above-background concentrations of uranium were found in other wells near the site. The FMPC reported this information to the State in November 1981.

These findings prompted an expansion of groundwater monitoring at the site. The FMPC began sampling existing private wells in the area in February 1982. Also in the early 1980s, 23 wells were drilled primarily in the waste pit area and in other nonproduction areas to identify the extent of the contamination. Some of these wells are sampled as part of the RCRA Groundwater Assessment Program.

By 1990, over 200 onsite monitoring and production wells, offsite monitoring wells, and privately owned wells were available for a comprehensive sampling program. The selection of sampling locations, frequency of sampling, and types of elements tested for in each monitoring well are determined by RCRA regulations, CERCLA regulations (specifically the RI/FS requirements), and DOE guidelines. The separate RCRA and RI/FS assessment programs are described below, as is the Environmental Monitoring Groundwater Surveillance Program which is expanding to become the Comprehensive Groundwater Monitoring Program. The private well sampling program continues under Radiological Environmental Monitoring as a service to local residents and as an additional source of offsite groundwater information.

The RCRA Groundwater Assessment Program began as a result of the disposal of the hazardous waste barium chloride in Waste Pit 4 from 1980 to 1983. Federal and state environmental regulations required the FMPC to identify whether hazardous waste had entered the groundwater, and, if so, to identify the rate, extent of migration, and concentration of any hazardous waste in the groundwater. These tasks were performed

first through a detection program and now through an assessment program. When the results from the RCRA Detection Program showed significant changes of indicator parameters, the FMPC began the RCRA Groundwater Assessment Program. This assessment program was begun in May 1988 and has provided valuable information on the quality of groundwater beneath the waste pit area. Analytical results of the sampling and assessment can be found in the *RCRA Annual Report for 1990.*

The RCRA Groundwater Assessment Program currently monitors water quality at 43 wells, all of which are within the FMPC boundaries. These monitoring wells are sampled quarterly for over 100 synthetic and natural materials, including sodium, chloride, and nitrates (common in fertilizers); metals such as iron, magnesium, and lead; and organic compounds like acetone (common in solvents), pesticides, and PCBs (used in electrical machinery).

Groundwater monitoring for the Remedial Investigation and Feasibility Study began in May 1988. This CERCLA-driven study is investigating the nature and extent of potential environmental impacts from past and current operations at the FMPC, with particular regard to the Great Miami Aquifer described in Chapter One. The major goals of the RI/FS are to determine the sources of past or present hazardous materials on the FMPC site, the pathways through which these contaminants could leave the site, and the most feasible methods of cleanup.

Since 1985, the total number of groundwater monitoring wells has increased from 32 to over 200. Many of these new monitoring wells were constructed as part of the RI/FS to identify contamination in the groundwater both on- and offsite. In order to ensure that the RI/FS program is monitoring for all possible contaminants, the samples are analyzed for selected radionuclides as well as nonradioactive materials on the Hazardous Substances List (HSL) published by the USEPA. The complete program is discussed in more detail in Chapter Ten.

The Environmental Monitoring Groundwater Surveillance Program has grown from simply monitoring the original 13 onsite wells to a ***Comprehensive Groundwater Monitoring Program***. In late 1989, all long-term groundwater monitoring responsibilities were shifted to the Environmental Monitoring group to ensure that the FMPC is in compliance with all applicable regulations and that the requirements for compliance are managed to eliminate duplication.

In 1990, 227 FMPC wells and 36 privately owned wells were sampled for radionuclides, general water-quality indicators, metals, and toxic organics. The results of these tests were channeled to the appropriate programs for assessment. Results are presented in this chapter as either private well results or as comprehensive sampling results.

Monitoring for Radioactive Pollutants

As part of the total liquid pathway, the movement of radioactive pollutants into and through the groundwater is of significant concern. Contamination in the aquifer has already caused some local residents and businesses to find alternate sources of drinking water, and cleanup costs are extensive. (There is already a removal action in place for the South Plume groundwater — see Chapter Ten.) This section discusses the results of private well sampling and of the FMPC comprehensive sampling program.

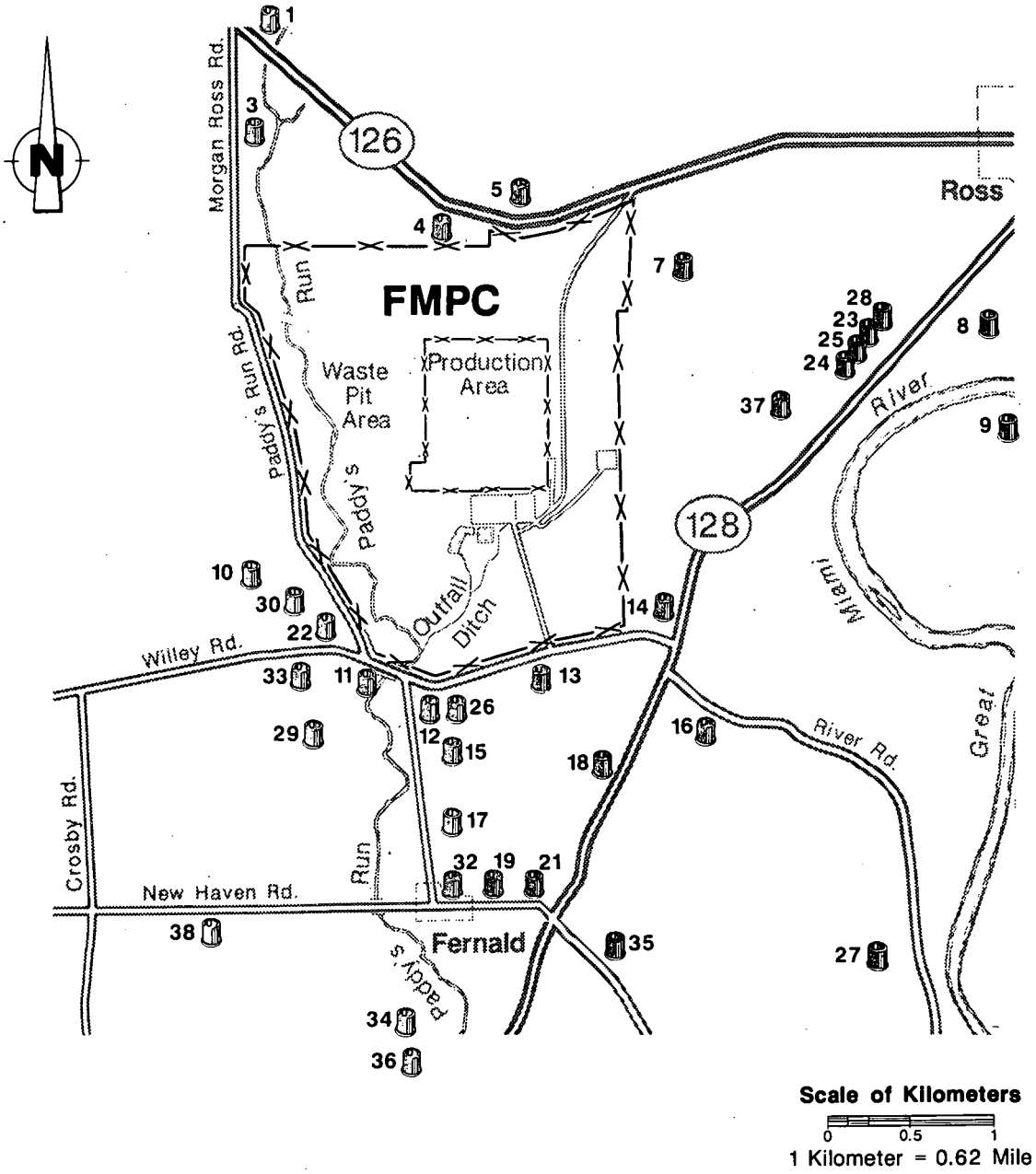
Private Well Sampling for Uranium

At the landowner's request, a private drinking water well near the FMPC site will be sampled for uranium to gain additional information about local groundwater quality. (Wells 33, 36, 37, and 38 were added to the program during 1990; well locations are shown in Figure 36.) The data from the private well sampling program are presented in Table 14, and Figure 37 shows average uranium concentrations found in offsite wells from 1988 to 1990.

During 1990, offsite wells belonging to individuals and companies in the vicinity of the FMPC were sampled monthly and analyzed for total uranium. Average uranium concentrations in all but three wells were less than 2.8 pCi/L, and therefore, less than 13% of the 22 pCi/L DOE drinking water guideline. These concentrations can also be compared to national natural levels for total uranium in groundwater of 0.068 to 6.8 pCi/L, and local natural levels for total uranium of 0.068 to about 2.2 pCi/L.[31, 32] These results are consistent with previous years. As in past years, only wells 12, 15, and 17 exceeded the DOE guideline in 1990. These are no longer used as sources of potable water.

In December 1990, the FMPC sampled an additional private well at the homeowner's request. This well, located about 4 km (2.5 miles) south of the site and on the north bank of the Great Miami River, had one sample with a total uranium concentration of 5.5 pCi/L. Although this concentration was within the DOE guideline, it was above the background range for the area. The FMPC will continue to monitor this well and other wells along a 1.6 km (1 mile) section of Ohio State Route 128 during 1991 to determine the range of uranium concentrations in the area.

FIGURE 36: Private Well Locations



LEGEND

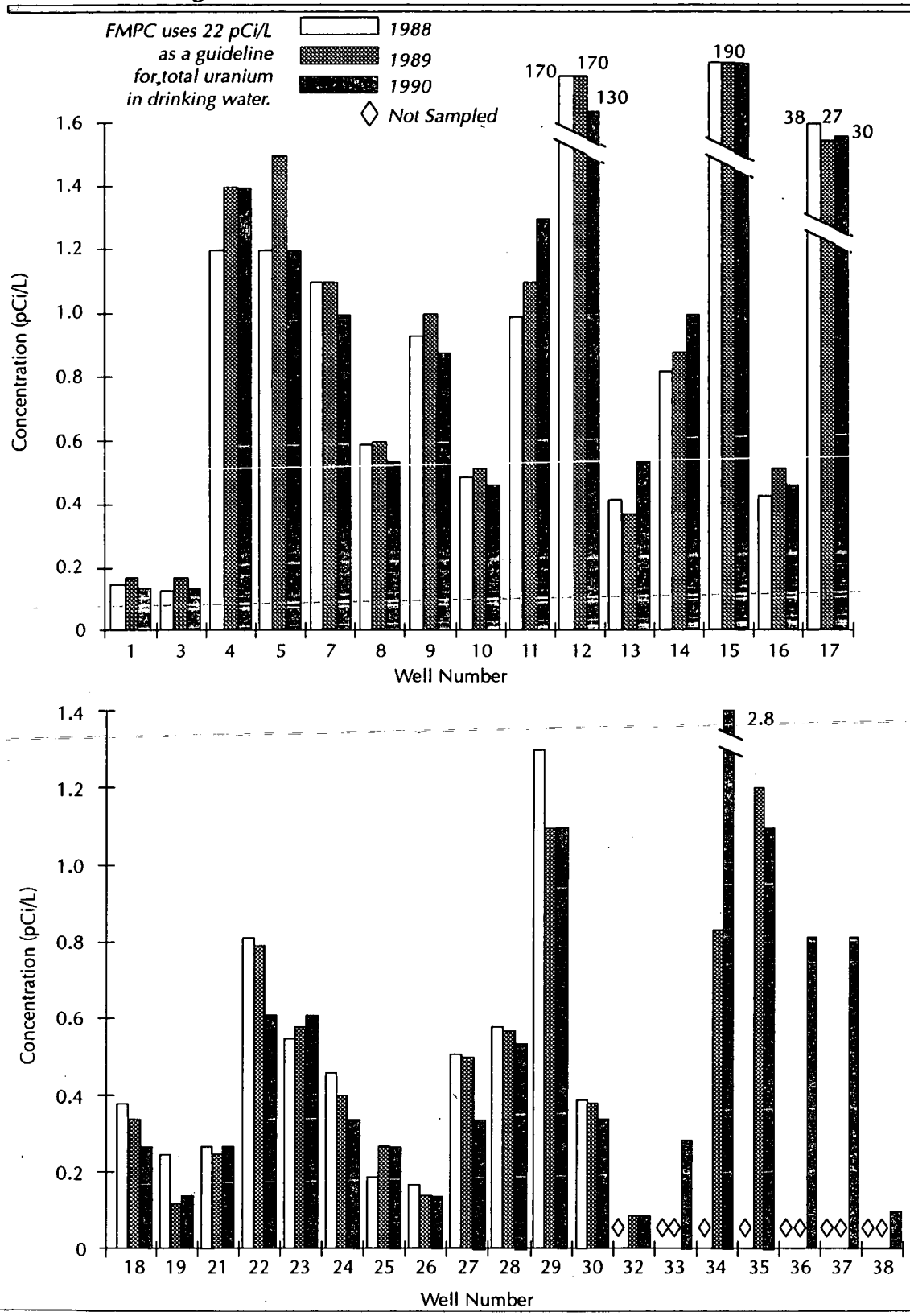
Sampling Location

Plant Perimeter

Production Area Perimeter

1302

FIGURE 37: Average Uranium Concentrations in Private Wells, 1988 to 1990



Comprehensive Sampling for Radionuclides

Radioactive elements primarily sampled for under the Comprehensive Groundwater Monitoring Program are radium, strontium, technetium, thorium, and uranium. Gross alpha activity, gross beta activity, cesium, plutonium, ruthenium, and neptunium in the groundwater are also monitored as indicators of radionuclide contamination. Although a total of 456 samples were taken for various radionuclides in 1990, not all were able to be analyzed for this report because of delays at the contract laboratory.

The depth of an FMPC well and the water-bearing zone it extends into are denoted by the first digit of the well number (Figure 39). Wells extending into the perched groundwater within the till are denoted as 1000-series wells (Figures 40 and 41). Wells extending into the upper portion of the sand and gravel aquifer are denoted as 2000-series wells (Figure 42). The 3000-series wells are placed within the middle portion of the sand and gravel aquifer, and the 4000-series wells are installed in the sand and gravel aquifer beneath a layer of "blue clay" (Figure 43). Sometimes a group of two or more wells of different depths are drilled at the same location to sample different water-bearing zones within the groundwater; these groups are called *cluster wells.*

The movement of uranium in the groundwater has been a key factor in determining the sources of contamination at the FMPC. Results from 219 samples at 157 on- and offsite locations were analyzed for uranium. The highest concentration was 8,379 pCi/L in the glacial overburden next to the waste pit area, well above guidelines. Uranium concentrations in 36 other samples at 34 onsite locations were also above the drinking water guideline. These 37 above-guideline sample concentrations are listed in Table 15.

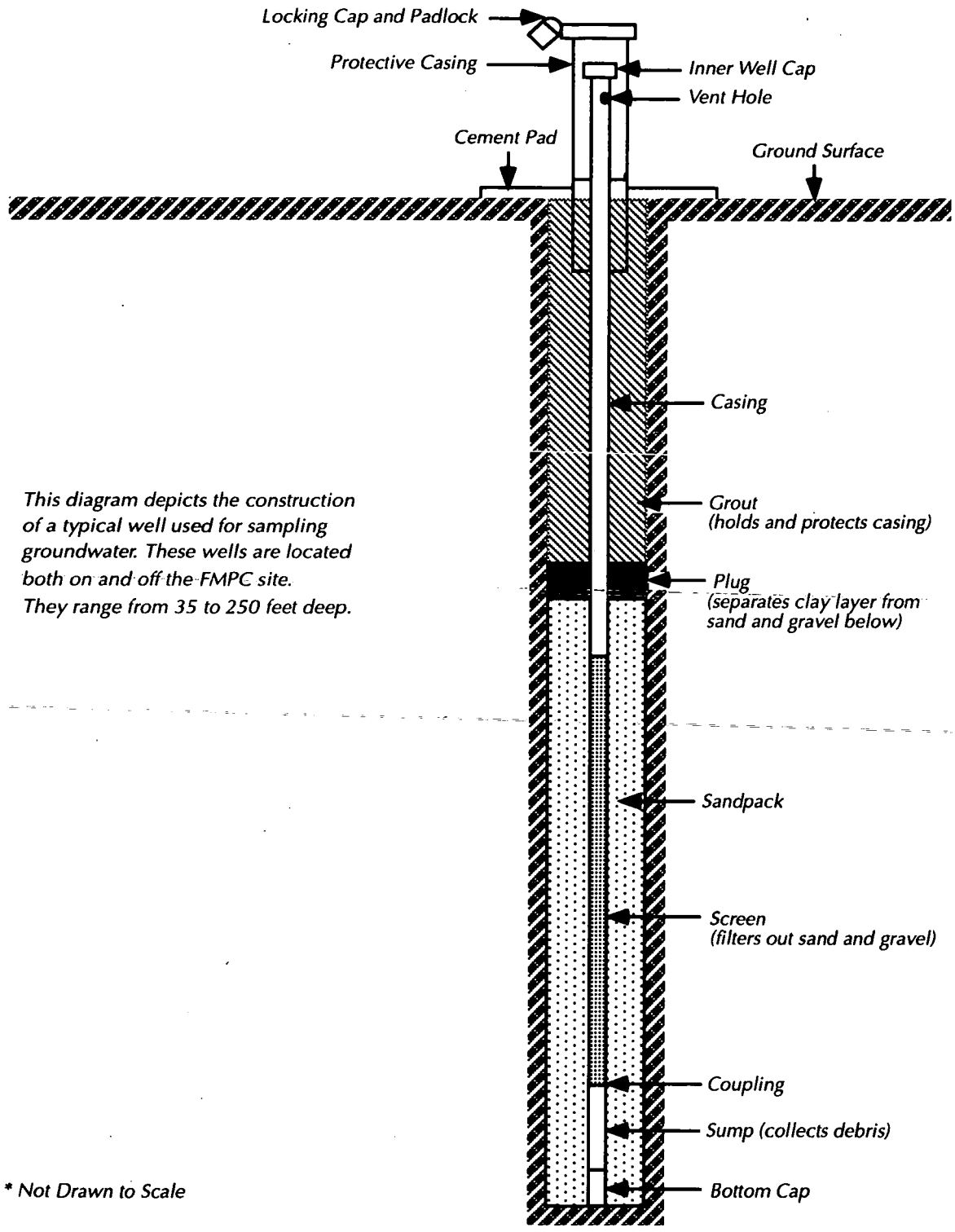
Aside from uranium, other radionuclides of concern at the FMPC are thorium, radium, strontium, and technetium (Table 16). Groundwater monitoring for thorium consisted of analysis of 158 samples collected at 113 monitoring locations. Only the thorium-232 isotope was detected at concentrations above the 2 pCi/L DOE guideline; the highest of five above-guideline concentrations was 4.1 pCi/L in the glacial overburden in the southeast corner of the Production Area.

Monitoring for radium included analysis of 125 samples from 99 wells. Four samples showed concentrations of total radium above the 5 pCi/L DOE guideline, and the highest of these was 20 pCi/L in the water table zone of the sand and gravel aquifer, south of the Sewage Treatment Plant and east of the Production Area.

Only two of 38 strontium samples and only two of the 70 technetium samples were at concentrations above the respective guidelines. These occurrences were in the water table zone of the sand and gravel aquifer.

(Text continues on page 118.)

FIGURE 38: Well Diagram*



This diagram depicts the construction of a typical well used for sampling groundwater. These wells are located both on and off the FMPC site. They range from 35 to 250 feet deep.

* Not Drawn to Scale

FIGURE 39: Monitoring Well Depths and Screen Locations

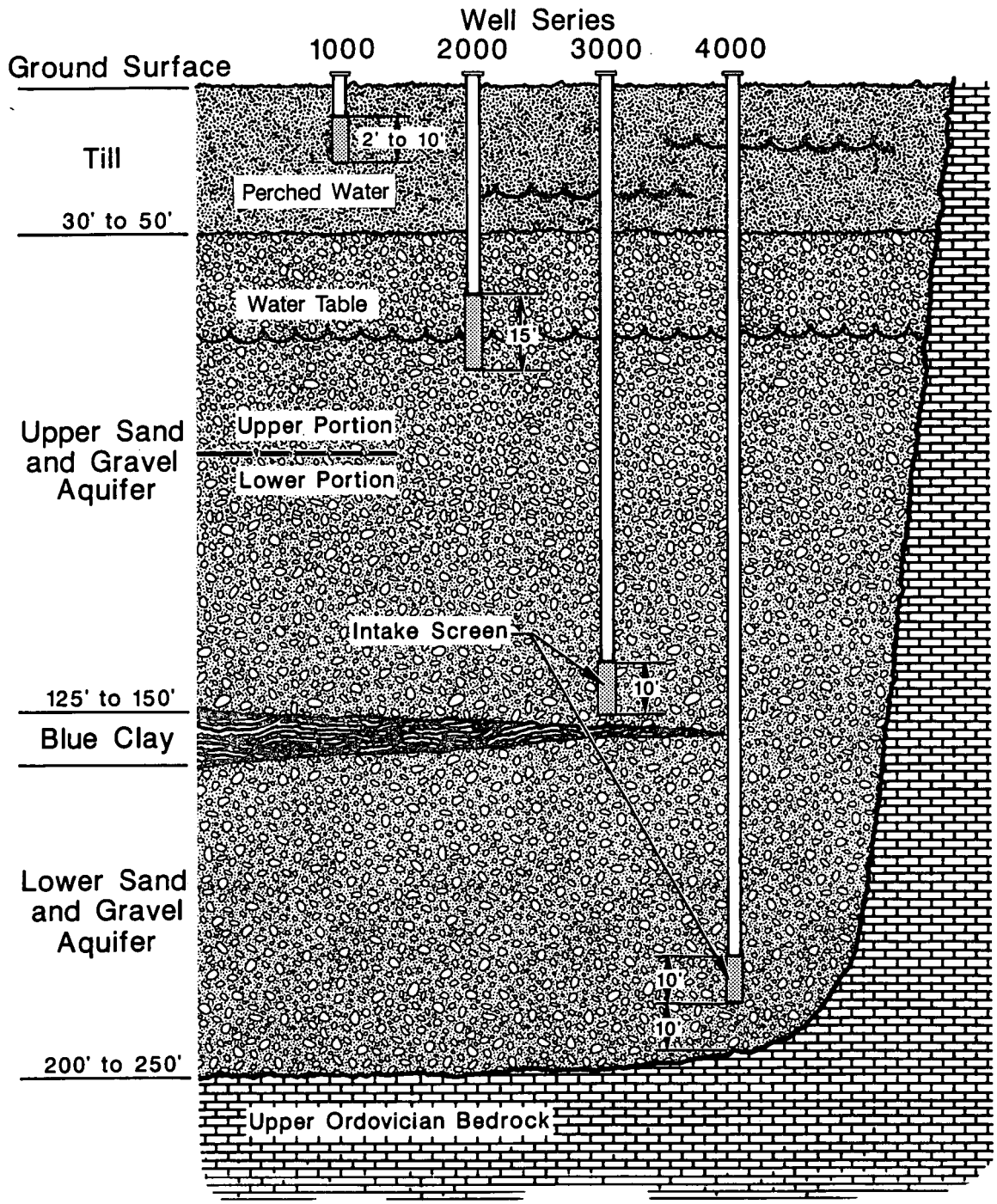


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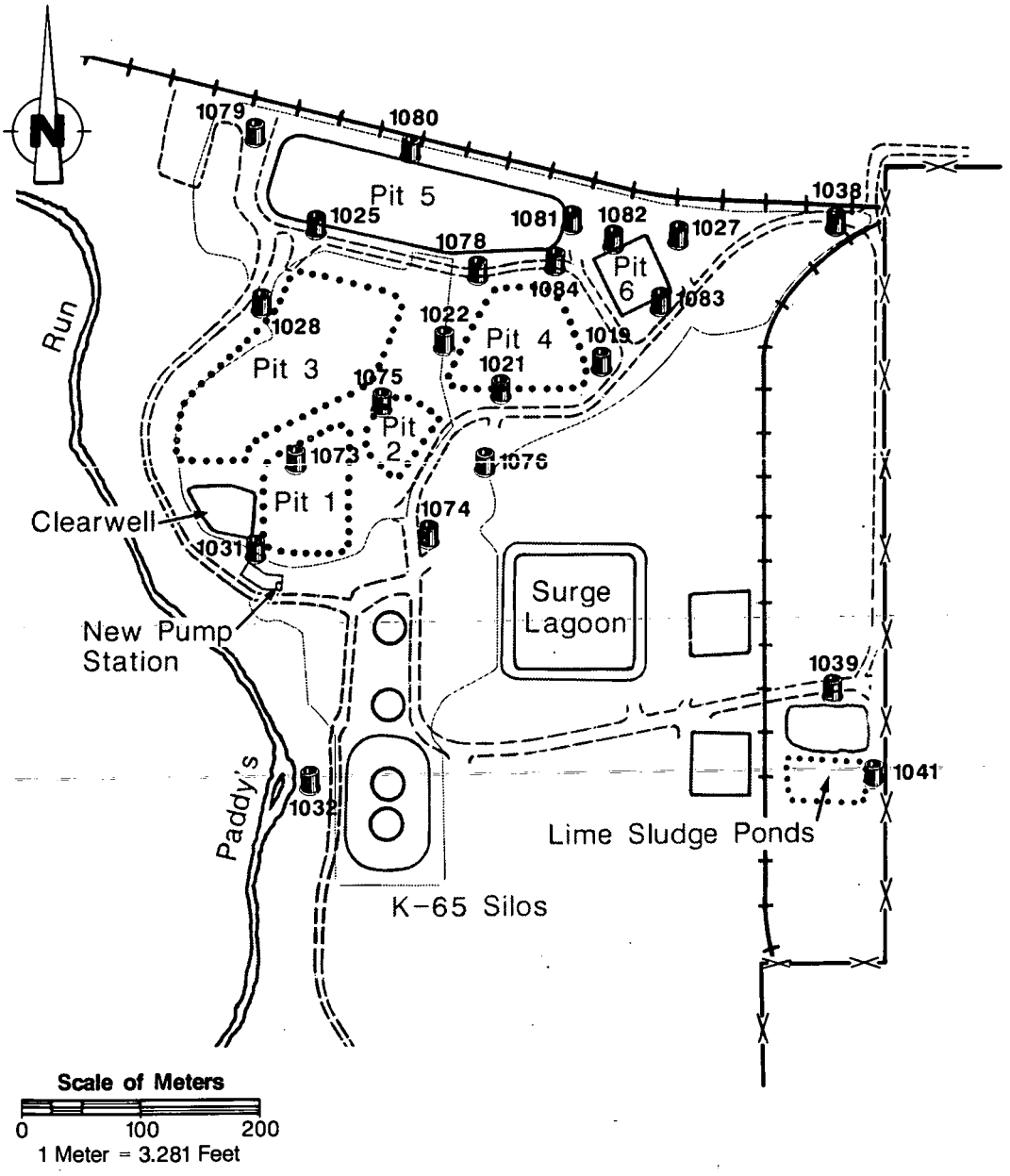
FIGURE 40: 1000-Series Monitoring Wells in the Waste Pit Area

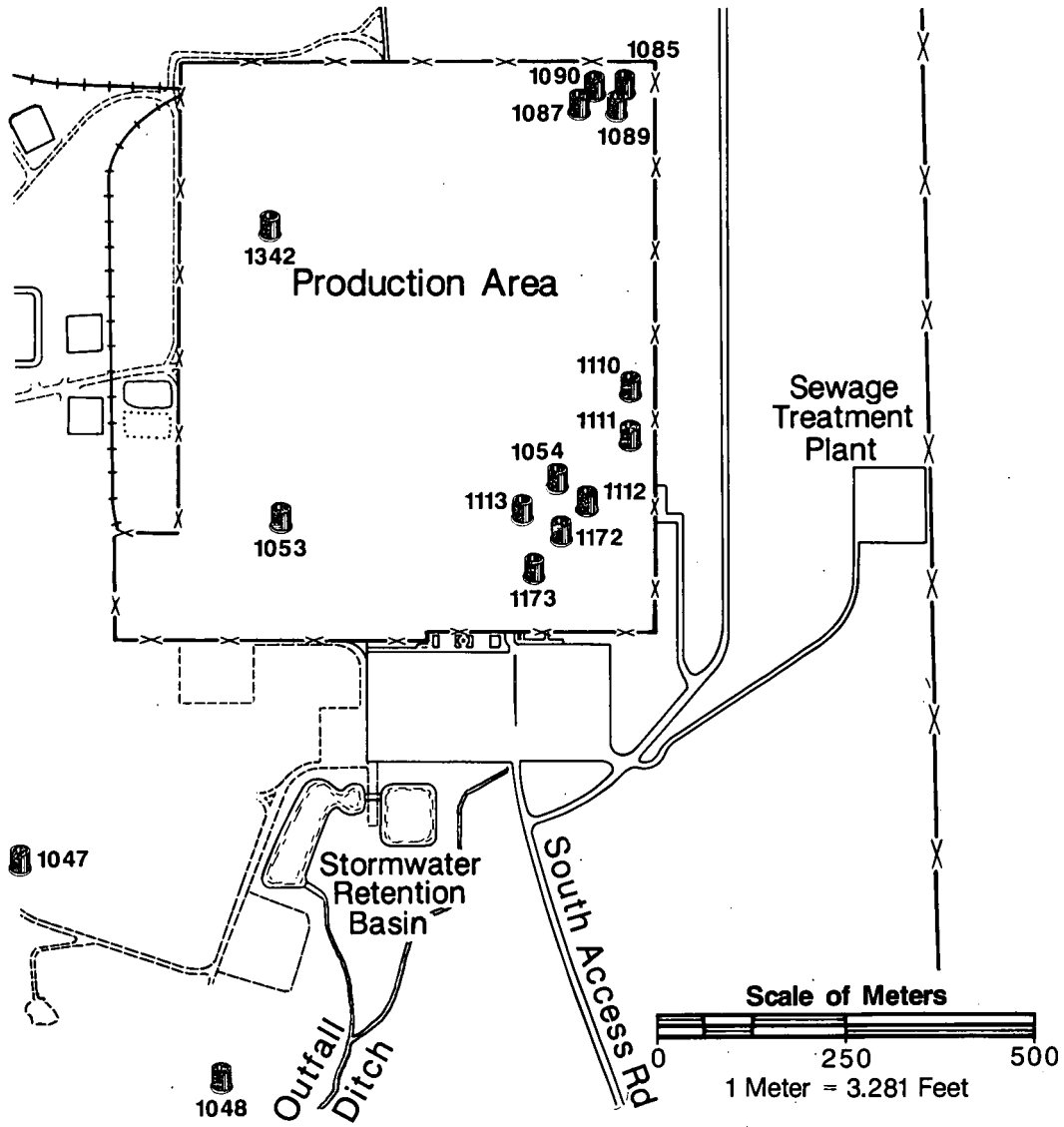


LEGEND

- 1000 Series Monitoring Network
- ••••••• Covered Pit
- ×–×–× Production Area Perimeter

1302

FIGURE 41: 1000-Series Monitoring Wells in the Production Area

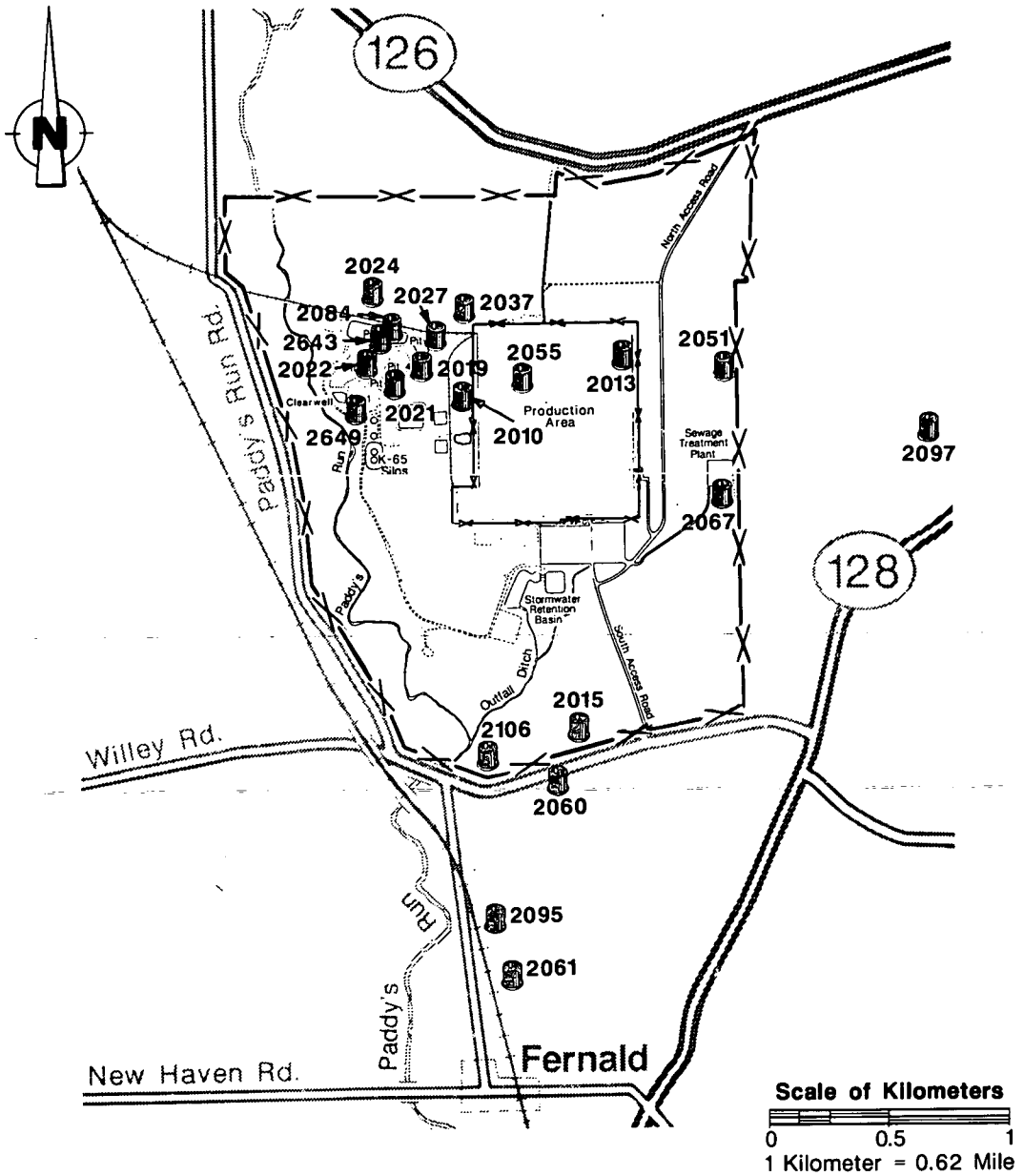


LEGEND

- 1000 Series Monitoring Network
- Plant Perimeter
- Production Area Perimeter

1302

FIGURE 42: 2000-Series Monitoring Wells

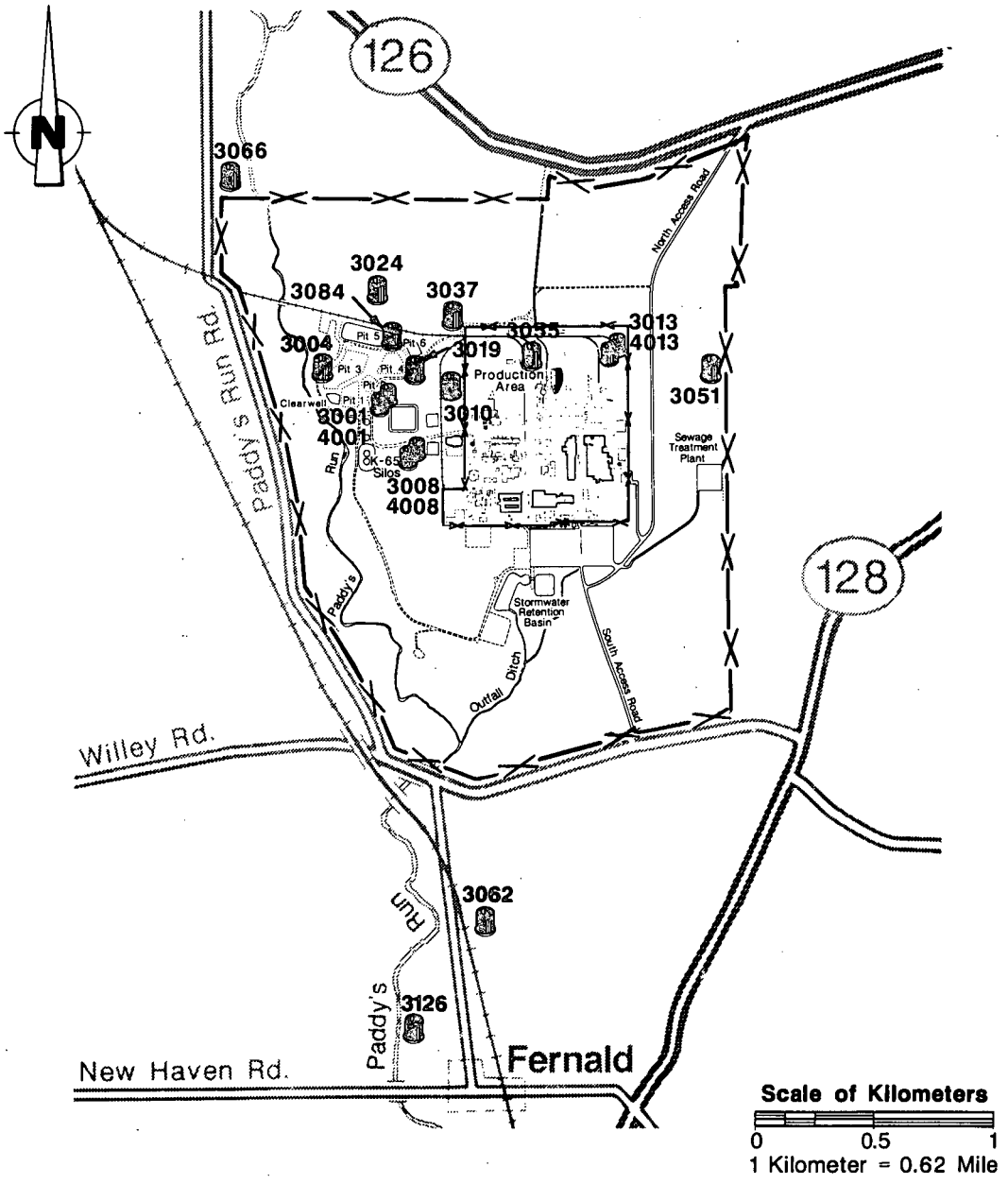


LEGEND

- 2000 Series Monitoring Network
- Plant Perimeter
- Production Area Perimeter

1302

FIGURE 43: 3000- and 4000-Series Monitoring Wells



LEGEND

- 3000 and 4000 Series Monitoring Network
- 3000 Series Monitoring Network
- Plant Perimeter
- Production Area Perimeter

1302

Finally, gross alpha activity was monitored to indicate areas of concern for radionuclides. Thirty-eight of 95 samples taken to detect gross alpha indicated activity above the DOE guideline. These locations, particularly in the Production Area, continue to be carefully monitored. More detailed groundwater results can be found in the *1990 Groundwater Monitoring Annual Report.*

Monitoring for Nonradioactive Pollutants

Protection of the Great Miami Aquifer from FMPC contaminants includes monitoring for a number of nonradioactive pollutants listed in the National Primary and Secondary Drinking Water Regulations. Primary standards apply to those substances which pose definite health threats if present beyond the regulated concentrations; secondary standards control contaminants that primarily affect the aesthetic qualities of drinking water and are not federally enforceable.[33] In addition to comparing private and FMPC well samples to these standards, onsite groundwater is also sampled as part of the RCRA Groundwater Assessment Program.

Private Well Sampling for Metals

The July 1990 samples from the private wells were analyzed for the 16 metals listed in Table 17. Of these 16 metals, no DOE or USEPA standards have been established for calcium, magnesium, nickel, potassium, and sodium. Although concentrations of iron and manganese were higher than the secondary drinking water guidelines in a number of wells, high concentrations of those natural elements are typical for groundwater in this area.[5, 16, 33] All other metal concentrations were well within the appropriate guidelines.

Comprehensive Sampling for Hazardous Substances

The Comprehensive Groundwater Monitoring Program samples for nonradioactive constituents in the groundwater to identify areas that might have harmful chemical concentrations as a result of production operations. The list of nonradioactive constituents sampled for comes from the USEPA's Hazardous Substance List. This section focuses on the pollutants of primary concern at the FMPC. A complete list of all of the chemicals sampled for at the FMPC in 1990, along with the sampling results, can be found in the *1990 Groundwater Monitoring Annual Report.*

Contamination indicators include pH, conductivity, total dissolved solids, total organic carbon, and total organic halogens. Since groundwater characteristics are normally stable, changes in the measures or concentra-

tions of these constituents indicate that the groundwater may be contaminated. The results of all comprehensive sampling for nonradioactive contaminants and water quality indicators have identified the waste pit area, the Production Area, the Southfield Disposal Area, and the South Plume Area as areas of contamination. Monitoring will continue in these areas to determine the extent of the pollution.

The FMPC samples for the following chemicals because they are a threat to public health:

- Arsenic
- Barium
- Cadmium
- Chromium
- Fluoride
- Lead
- Mercury
- Nitrate
- Selenium
- Silver
- Volatile Organic Compounds (VOCs).

The FMPC compares groundwater samples to maximum contaminant levels for drinking water sources. Analyses of samples from onsite wells have indicated that arsenic, cadmium, nitrate, and some VOCs have been detected in concentrations exceeding drinking water maximum contaminant levels.

Arsenic concentrations above the 0.05 mg/L maximum contaminant level were detected only in well 3066, at the outlet of the Shandon Valley Aquifer which is northwest of the Great Miami Aquifer (Figure 43). Concentrations of arsenic in this well ranged from 0.082 to 0.11 mg/L in 1990. No other monitoring locations have indicated concentrations of arsenic above the regulated maximum contaminant level. Since well 3066 is upgradient to the FMPC, it is not likely that the levels of arsenic are related to site activities.

Cadmium was detected in concentrations above the regulated maximum contaminant level of 0.01 mg/L in only two locations. A May 15 sample from well 3010 measured 0.069 mg/L, but in two subsequent samples from the well, cadmium was not detected. Well 1342 had a cadmium concentration of 0.012 mg/L.

Sixteen monitoring locations indicated nitrate concentrations above the 10 mg/L maximum contaminant level in 1990 (Table 18). Nitrates are used in many fertilizers, but because nitrates were also widely used in production processes at the FMPC, this contaminant is of significant concern to the FMPC. Nitrates in drinking water are a health hazard, especially to infants. Efforts are currently under way to determine the magnitude of the contamination.

Volatile organic compounds are synthetic chemicals typically found in the solvents used during the production process. Since VOCs are not naturally occurring, any detection is of concern. Of 197 monitoring locations sampled for VOCs in 1990, six indicated consistent concentrations of VOCs, and only two of these showed VOC concentrations above the maximum contaminant levels. The monitoring wells and the VOCs detected are listed below:

- **Well 1031** – 1,1,1-Trichloroethane; 1,1-Dichloroethane; 1,1-Dichloroethene; 1,2-Dichloroethane; 1,2-Dichloroethene (total); acetone; methylene chloride; tetrachloroethene; toluene; trichloroethene;
- **Well 1041** – 1,1-Dichloroethane
- **Well 2015** – 1,1,1-Trichloroethane
- **Well 2060** – 1,1,1-Trichloroethane
- **Well 2649** – 1,1,1-Trichloroethane; 1,1-Dichloroethane; 1,2-Dichloroethene (total); trichloroethene
- **Well 3126** – acetone.

Wells 1031 and 2649 indicated concentrations of trichloroethene in ranges of 0.137 to 0.334 mg/L (the regulatory maximum contaminant level is 0.005 mg/L.) All other VOC detections were below the maximum contaminant levels. Work is continuing to define the magnitude of the VOC contamination in these areas.

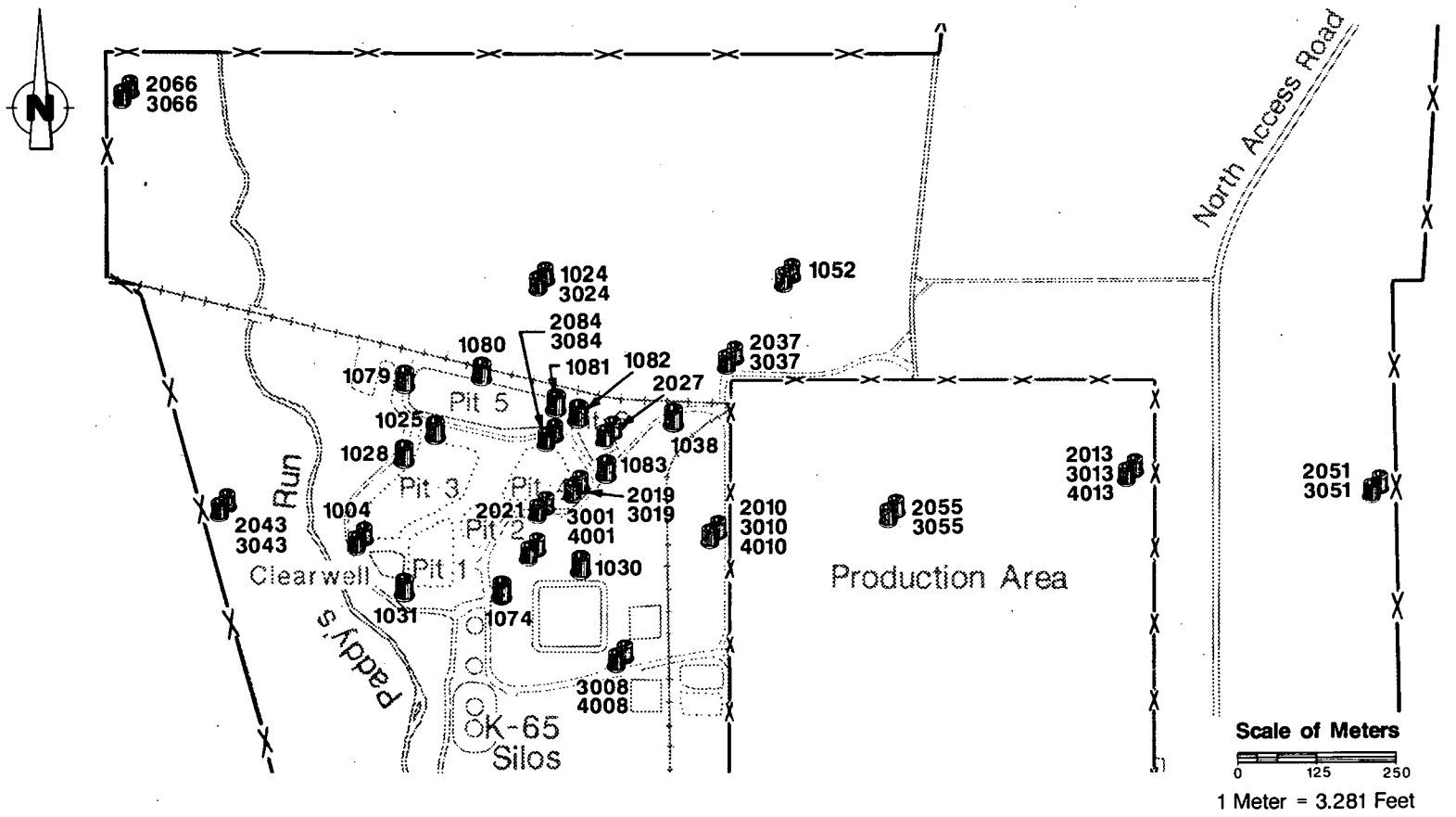
Onsite Sampling for Hazardous Waste as Part of RCRA Program

The RCRA Groundwater Assessment Program for Waste Pit 4 sampled 43 wells in February, May, August, and November 1990 (Figure 44). RCRA regulations do not include radioactive substances, rather, the RCRA assessment analyzed these samples for inorganics, VOCs, and general water-quality indicators. Because previous assessments have already identified significant levels of nonradioactive constituents in the groundwater near the waste pits, the purpose of the RCRA assessment is to determine the amount, rate of movement, and geographical extent of these constituents in the aquifer.

RCRA assessment work conducted in the waste pit area in 1990 indicated that 16 groundwater constituents and pH measurements were significantly above background in 13 of the wells. Table 19 lists the parameters and the wells in which they were statistically significant.

Isoconcentration contour maps were developed for some of the constituents in order to illustrate the extent of contamination in the sand and gravel aquifer, and sulfate was shown to have migrated the farthest.[7]

FIGURE 44: Well Locations for RCRA Assessment



LEGEND

Single Well | Cluster Well | Production Area Perimeter | Plant Perimeter

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Work will continue to determine the movement of constituents in order to identify the best methods and most effective locations for cleanup.

In June 1990, the assessment program verified that a number of organic constituents were detected in well 1031, located in the glacial overburden next to the Waste Pit Area. A 2000-series well was constructed downgradient to the contaminated 1000-series well to see if the contaminants had migrated into the sand and gravel aquifer. The 2000-series well was first sampled in November 1990 and the results indicated that it may contain similar organic constituents. Work is continuing to confirm these findings and determine the magnitude of the contamination in that area.

Summary of Liquid Pathway: Groundwater Monitoring Results

In 1990, the various groundwater monitoring programs were further consolidated into the Comprehensive Groundwater Monitoring Program, and private well sampling continued as a separate program. Results of private well sampling for uranium were consistent with past years, and only three wells, no longer used for drinking water, showed concentrations above the DOE guideline. Comprehensive sampling of FMPC wells showed above-guideline uranium concentrations in certain areas, and these continue to be carefully monitored. Only a few samples had concentrations of thorium, radium, strontium, and technetium above guidelines. Sampling for nonradioactive pollutants by the comprehensive sampling program has shown areas of concern for several nonradioactive contaminants, including nitrates, VOCs, and sulfate. Removal actions to clean up these contaminated areas are discussed in Chapter Ten. Next, Chapter Seven uses the concentrations of radionuclides reported here and in the previous two chapters to estimate radiation doses for 1990.

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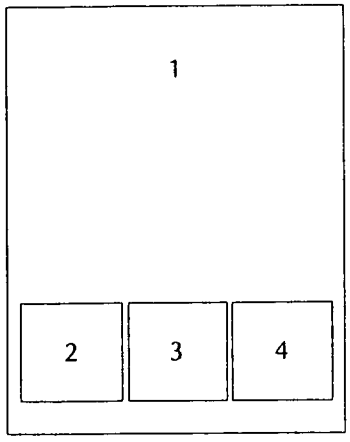
CHAPTER 7



1 – Because the FMPC is situated in a farming community, potential radiation dose from eating locally grown produce is estimated.

2 – Radiation dose from beef of local cattle is also estimated as part of the air pathway.

3 – Air monitoring stations provide data for estimating doses from airborne radionuclides.

4 – The FMPC estimates potential dose from drinking Great Miami River water, even though the river is not a source of drinking water downstream of the site.

CHAPTER SEVEN

Estimated Radiation Doses for 1990

One of the chief public concerns about any facility that handles radioactive materials is that people working and living in the area may be exposed to harmful amounts of radiation. One way the FMPC addresses this concern is by monitoring the ways in which radioactive material could be moving through the environment and reaching people. Since there are technical as well as practical problems in trying to directly measure the dose people may actually receive from the FMPC, dose is estimated using models and the results of environmental samples. This chapter explains how dose estimates are calculated, provides the 1990 dose estimates from several different pathways, and interprets the significance of the estimated doses.

Results in Brief: 1990 Estimated Doses

DOE orders and USEPA regulations require that the FMPC demonstrates that its radionuclide airborne emissions are low enough to ensure that no one in the public receives an effective dose of 10 mrem in any one year.[13, 15] (This excludes radon emissions which are covered under a different part of the regulation.)[34] Moreover, to show that the site is well within the DOE limit of 100 mrem* dose from all exposure pathways, the FMPC estimates doses from other components of the air and liquid pathways as well as direct radiation from the K-65 Silos. These doses for 1990 are presented in Table 20 and are also summarized below.

Air Pathway

CAP-88 modeling – The estimated maximum effective dose to a member of the public from 1990 airborne emissions was calculated as 0.6 mrem.

Produce – The estimated committed effective dose from eating produce grown in the area was 0.01 mrem.

Beef – The estimated committed effective dose from eating beef raised near the FMPC was 0.001 mrem.

Liquid Pathway

Great Miami River – The estimated committed effective dose from drinking river water downstream of the FMPC effluent line was 0.02 mrem.

Groundwater – The estimated committed effective dose from drinking water from the most contaminated offsite well was 32 mrem. This well did not supply drinking water during 1990 — it was used for monitoring purposes only.

Fish – The estimated committed effective dose from eating fish from the river near the FMPC effluent line was 0.01 mrem.

Direct Radiation Pathway

The maximum estimated dose from direct radiation to the person living closest to the K-65 Silos was 9 mrem for 1990.

Dose from Radon

The estimated committed effective dose from average radon concentrations at the FMPC fenceline was 69 mrem, which is similar to last year's dose.

*The DOE limit of 100 mrem per year from all pathways is the sum of the doses from radiation external to the body during the year plus the dose from radionuclides taken into the body during the year. This latter dose is called the committed effective dose, received over a 50-year time period.

Environmental and Dose Modeling

As described in Chapter One, pathways are the routes along which radioactive material moves and may deliver dose to the public. Air and liquid pathway monitoring provide the bases for the extensive environmental sampling described in Chapters Four, Five, and Six. (Direct radiation is measured by dosimeters.) From this information, a dose from each pathway can be estimated by using a model which predicts the estimated dose to people. The FMPC, like many other facilities, uses models extensively to estimate doses to the public. These models are briefly explained in the following paragraphs.

An environmental model is a way to represent a complex environmental process (such as atmospheric dispersion of emissions or the air-to-soil-to-produce process) as a simple set of mathematical formulas. By studying an environmental process, such as dispersion of a pollutant from a stack as it is carried by the wind, a mathematical formula can be developed that models the process. This model can then be used to predict the concentration of the pollutant at a specific location. As additional processes are modeled, it is possible to interconnect them so that the movement of pollutants is predicted by a larger environmental model.

Dose models are developed similarly. By modeling radioactive decay, absorption and removal of radioactive materials in the body, and other physical and biological processes, a dose model can be constructed to evaluate how radioactive materials deliver a dose. Connecting the dose model to the environmental model provides a means of estimating dose using information gathered through environmental sampling. Models are usually translated into computer programs, known as codes, to conveniently handle the data and calculations.

Models play an important role in environmental monitoring because current technology makes it impractical to measure environmental doses with instruments. The nature of radioactivity and the presence of naturally occurring radioactive materials creates difficulties in distinguishing between natural radioactivity and radioactivity from the FMPC. Models also estimate pollutant concentrations and doses which are below the detection capabilities of instruments and laboratory measurements. These concentrations and doses would be left out of the environmental impacts of the FMPC if models were not used.

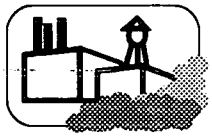
Although models may be the only comparative way for scientists to estimate dose, they do not necessarily predict all environmental processes. Since the mathematical formulas that represent the environmental and biological processes are simplifications and generalizations, applying them to the specific conditions at the FMPC may lead to differences

between predicted and actual concentrations or doses. The results or outputs of models always involve some uncertainty in the accuracy of the estimated dose, and many have built-in assumptions which strongly influence the results. The most beneficial use of models may be their ability to estimate the upper limit of the dose and identify the most influential pollutant or pathway of exposure.

Air Pathway Dose Calculations

The air pathway includes contaminants reaching people directly as emissions and indirectly through produce and beef contaminated by airborne emissions. This section uses data from these primary and secondary routes (see Chapter Four) to calculate doses.

Dose from radon is presented as a separate section of this chapter. The DOE is assessing the Derived Concentration Guides for radon; therefore, dose from radon is not included in the dose to the maximally exposed individual. The NESHAP requirements of the Clean Air Act specifically exclude dose from radon when considering air pathway doses.



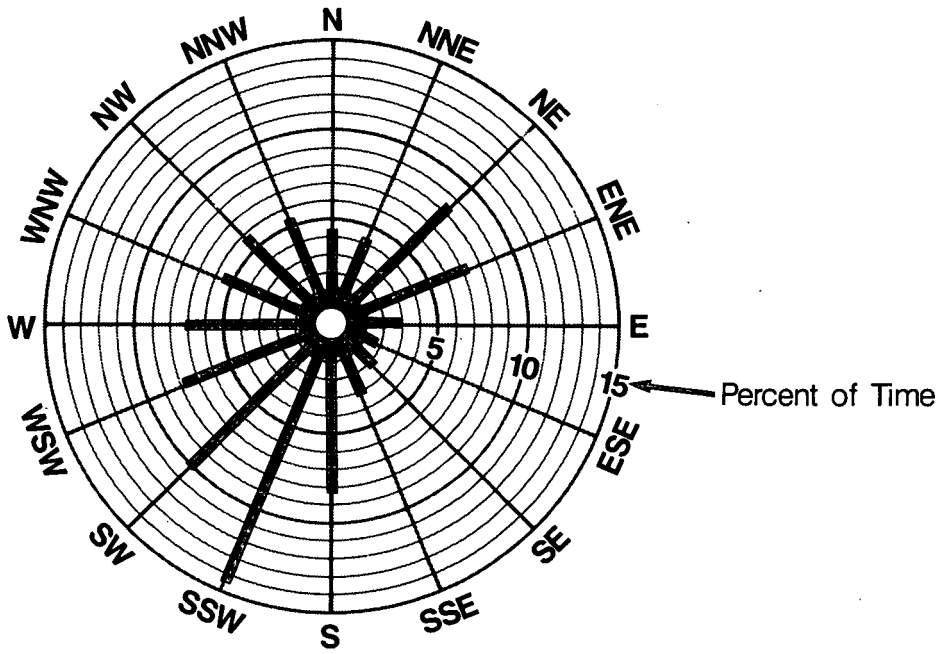
Estimated Doses from Airborne Emissions

At the FMPC, dose estimates from airborne emissions are obtained using a set of computer codes called CAP-88. USEPA regulations require the FMPC to use CAP-88 to determine compliance with the NESHAP requirements of the Clean Air Act. Within the CAP-88 set of codes, the AIRDOS code calculates concentrations of radionuclides in air, on the ground, and in food based on estimates of the amount of airborne radioactive material released. The concentrations are then used to calculate the intakes and subsequent doses to people.

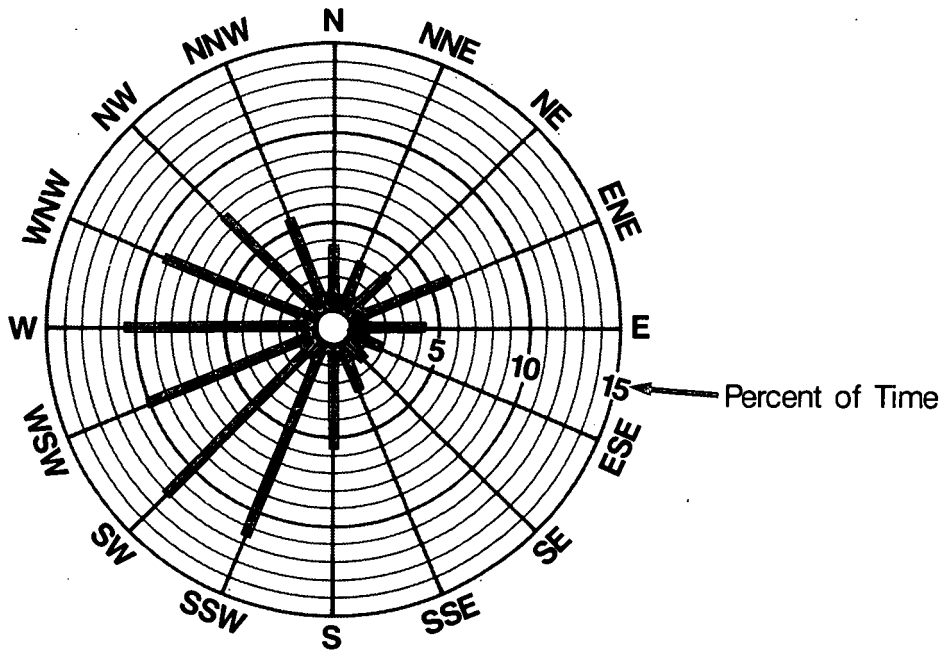
The CAP-88 codes calculate both individual and collective doses. Collective dose is the sum of individual doses to people in the FMPC area and is reported in the units of person-rem. (For example, if 10 people each receive 1 rem, the collective dose is "10 person-rem"; if 20 people each receive 0.5 rem, that collective dose also is "10 person-rem.") Person-rem are used as broad measures of the radiological impacts of the FMPC and are useful in comparing the risks from FMPC operations with other facilities and industries.

The CAP-88 codes require a large amount of data to estimate dose. The number and height of release points, wind speed and direction, the amount of radioactive material released, and population distribution in the FMPC area are examples of required data. (Wind rose data are shown in Figure 45, and estimated airborne radionuclide emissions and popula-

FIGURE 45: Wind Rose Data, 1990



60 Meter Height Showing Direction from which the Wind Blows



10 Meter Height Showing Direction from which the Wind Blows
[70% data recovery in 1990]

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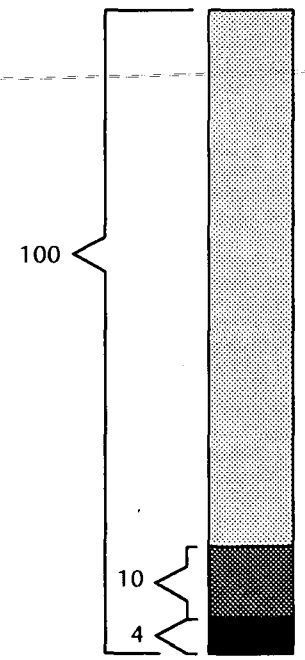
tion distribution are presented in Tables 21 and 22.) Although many of the data were obtained through measurements and sampling, some data were not readily available and were estimated. Examples of such data are the amounts of airborne radioactive material released from the waste pits, Laboratory Building, and Water Cooling Towers. The FMPC made very ***conservative*** estimates for these and all other emission sources which were not measured directly. Conservative estimates, used frequently in environmental monitoring and dose calculations, are based on assumptions about an exposure situation that should result in the highest estimate of a dose. For example, an assumption about estimated doses at the air monitoring stations is that a person is at one location for 100% of the time during a year. The assumptions are conservative in the sense that they provide a margin for error. Conservative estimates of emissions were used to ensure that dose estimates were not underestimated, but were the maximum doses that could have resulted from FMPC operations during 1990.

Results of the CAP-88 codes estimated the maximum dose from 1990 airborne emissions to be 0.6 mrem to a person located 1,500 meters (4,920 feet) north of the center of the FMPC production area. This dose estimate assumed that the person remained outside his or her home 100%

FIGURE 46: Department of Energy Dose Limits



Regulations which limit specific pathway doses provide a reference point for measuring the FMPC's compliance. DOE Order 5400.5 charges that no individual in the general public shall be exposed to 100 mrem/year, from combined sources, as a result of site operations during any year.

This order further indicates that no individual in the general public shall receive 10 mrem/year from the air pathway (excluding radon). This standard is adopted from the National Emission Standards for Hazardous Air Pollutants of the Clean Air Act.

Finally, the order mandates that no person in the general public shall receive greater than 4 mrem/year from drinking water. This standard conforms to National Primary Drinking Water Standards of the Safe Drinking Water Act.

Method Used to Determine Airborne Emissions

Measured and estimated uranium emissions for 1990 totaled 3.2 kg (7 pounds). This represents about a tenfold reduction from the 1989 air emissions. The large decrease is directly attributable to the cessation of production in 1989. Uranium discharges from monitored stacks were the only emissions that were actually measured; emissions from all other sources listed here were estimated.

These 1990 airborne emissions used in the CAP-88 computer codes were organized as follows:

Emission Category	Percentage of Uranium Emission	Sources	Comments
Monitored Stacks	0.1%	Only 2 stacks.	Decrease from 33 stacks in 1989 reflects end of production.
Unmonitored Stacks	2.6%	Decontamination and decommissioning building and Plant 8.	Some estimated emissions were from the processing of wastes for shipment offsite.
Water Cooling Towers	52.3%	Cooling towers at the Boiler Plant.	Estimated using uranium concentration of cooling water and loss of water as a mist.
Building Vents	0.002%	Air supply and ventilation ducts.	Estimated from monitors set up only in areas of highest suspected concentration.
Lab Emissions	0.08%	Exhausts from fume hoods where radioactive materials are analyzed.	Estimated based on number and uranium concentration of samples.
Fugitive Emissions from Waste Pits	44.9%	Uranium-contaminated soil and dust from the waste pits.	Estimated according to USEPA method.[35]
Other Radionuclides	——	Uranium emissions which contain cesium-137, radium-226, thorium-230, and other radionuclides.	Estimated using radionuclide ratios typically found in waste pit and air samples.

of the time in 1990. The dose was below the NESHAP standard of 10 mrem from the air pathway and was only a fraction of the DOE guideline of 100 mrem/year from all pathways.

The collective effective dose from 1990 airborne emissions (not including radon) to the population within 80 km (50 miles) of the FMPC was also calculated by CAP-88. This dose was estimated to be 5 person-rem for a population of 2,600,000. For comparison, the same group of people received an estimated collective effective dose of 260,000 person-rem from natural radiation, excluding radon.

Estimated Dose from Eating Produce Grown near the FMPC

Since the CAP-88 codes calculated doses from only 1990 airborne emissions, additional dose calculations were made to estimate doses from past emissions that may have accumulated through the food chain. These additional calculations show potential dose from eating local vegetables and beef.

Uranium deposited on soil during the years the FMPC was in production may be absorbed by produce and therefore deliver a secondary pathway dose. This estimated dose is based on the conservative assumption that 100% of a person's diet of fruit and vegetables comes from gardens and farms in the FMPC area; this model diet assumes an annual consumption of 45 kg (100 pounds) of above-ground vegetables, 68 kg (150 pounds) of fruit, and 28 kg (62 pounds) of below-ground vegetables.[36] Tomatoes, apples and potatoes sampled from local gardens and farms were analyzed for uranium to represent the foods in the diet. Dose conversion factors convert the intake of a particular radionuclide to dose. The conversion factors themselves are the result of modeling the radioactive decay and metabolism of radionuclides in the body.[37] The effective dose received over the course of 50 years was calculated to be 0.01 mrem, a fraction of the DOE dose limit of 100 mrem per year for all pathways. As a comparison, the effective dose received from produce grown at background locations was calculated to be 0.01 mrem as well.

Estimated Dose from Eating Beef of Local Cattle

The FMPC also estimated the dose that a person might receive from eating beef raised near the site. The estimated dose is based on the conservative assumption that 100% of a person's diet of beef, a total of 32 kg (70 pounds) per year, comes from farms in the FMPC area.[36] Beef sampled from a local farm and analyzed for uranium was used to represent the diet. The effective dose received over the course of 50 years was calculated to be 0.001 mrem, which is not significantly different from the dose received from beef raised several kilometers from the FMPC.

Estimated Doses at the Air Monitoring Stations

Average air concentrations of uranium and other radionuclides measured at the seven fenceline air monitoring stations were entered in a variation of the CAP-88 codes which calculates dose using measured air concentrations. Table 23 presents the estimated committed effective doses that could be accumulated for the next 50 years by a person breathing the air at any one of the stations 100% of the time during 1990.

By comparing doses obtained by this method with doses obtained by models using estimated emissions, an evaluation can be made of the accuracy of the estimated emissions. If these dose estimates are similar, then an accurate estimate was made for unmeasured, unmonitored airborne emissions.

A comparison of doses calculated from estimated and measured emissions is presented below. The good agreement between doses based on estimated and measured emissions suggests that the emission estimates were reasonably accurate.

Comparison of Estimated and Measured Effective Dose at Air Monitoring Stations
Dose (mrem)

AMS Number	Estimated Using Model	From Measured Concentrations
1	0.5	0.2
2	0.2	0.2
3	0.2	0.3
4	0.08	0.1
5	0.06	0.1
6	0.1	0.2
7	0.09	0.2

Liquid Pathway Dose Calculations

Dose estimates from the liquid pathway are calculated using environmental sample results and dose conversion factors. Measurements of radionuclide concentrations in the Great Miami River, groundwater, and fish from the river are used to estimate dose from the liquid pathway. Description of the sampling programs for these environmental media are given in Chapters Five and Six.

Estimated Dose from Drinking Groundwater from Well 15

Although Well 15 (located just south of the FMPC — see Figure 36) is no longer used as a drinking water source, an estimate of the dose received from drinking water from the well is provided as a measure of the upper bound of the dose received from drinking well water in the FMPC area. Using a consumption rate of two liters of water per day and

the average 1990 uranium concentration, the effective dose received over the course of 50 years would be 32 mrem (Figure 47).[36]

Estimated Dose from Drinking Great Miami River Water

Although the Great Miami River downstream of the FMPC is not designated as a public water supply by the OEPA, the FMPC estimated the radiation dose to an individual if that person drank only the water from the river downstream of the FMPC discharge point after mixing had occurred. Assuming a daily consumption of 2 liters of water, the effective dose received over the course of 50 years would be 0.02 mrem (Figure 48).[36]

Estimated Dose from Eating Fish from the Great Miami River

To estimate dose from eating fish from the river, the average uranium concentrations in fish collected at the upstream, FMPC outfall, and Paddy's Run sampling locations (see Figure 32) were compared; the highest of these values was used to estimate the dose. Assuming an annual consumption of 4.4 kg (9.7 pounds) of fish from the Great Miami River, the effective dose received over the course of 50 years would be 0.01 mrem.[36] This dose is well below the DOE guideline of 100 mrem/year from all pathways.

FIGURE 47: Well 15 Dose

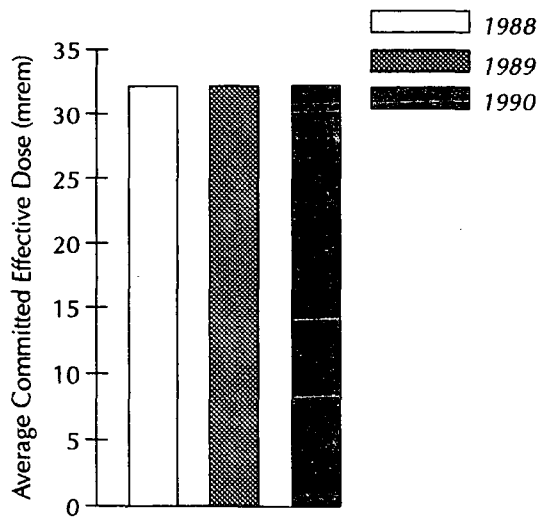
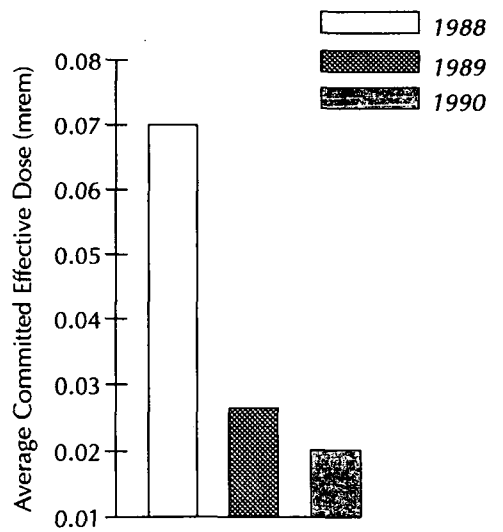


FIGURE 48: Great Miami River Dose



Direct Radiation Dose

Unlike the air and liquid pathways where a radionuclide delivers its dose after inhalation or ingestion, direct radiation dose is the effect of gamma radiation reaching nearby residents from radionuclides stored onsite, particularly in the K-65 Silos. This dose is measured rather than calculated.

Doses from direct radiation to people living near the site are periodically measured using a pressurized ionization chamber; longer term measurements are made with environmental thermoluminescent dosimeters (TLDs). The pressurized ionization chamber measurements are chiefly used to monitor the direct radiation emitted from the K-65 Silos, while the environmental TLDs are used to monitor direct radiation emitted from all the radioactive materials stored on site. The annual dose from direct radiation is calculated using net TLD results (typically four TLD results per year) from each location (Table 24). The annual dose from direct radiation in 1990 was estimated to be 9 mrem per year to the person living closest to the K-65 Silos. This dose assumes that the shielding provided by the house and the percentage of time the house is occupied reduces the dose by 50%.

Total of Doses to a Maximally Exposed Individual

The maximally exposed individual is a hypothetical member of the public who receives the highest calculated effective dose based on the location of his or her home, weather conditions, and the individual pathway doses. Since it is not possible to single out a specific individual in the FMPC area who receives the most dose, the results of the individual pathways and the AIRDOS evaluation are added to predict the maximum dose that a person could receive. The dose to the maximally exposed individual is a total of estimated doses from breathing 1990 airborne emissions, eating produce grown in the FMPC area, drinking water from the Great Miami River (even though the river is not a source of drinking water south of the FMPC), eating fish from the Great

Pathway	Dose	Applicable Guideline
Air		
Estimated 1990 emissions	0.6 mrem	10 mrem/air
Produce grown in FMPC area	0.01 mrem	100 mrem/all pathways
Beef raised in FMPC area	0.001 mrem	100 mrem/all pathways
Liquid		
Water from Great Miami River	0.02 mrem	4 mrem/drinking water
Fish from Great Miami River	0.01 mrem	100 mrem/all pathways
Direct		
At home near K-65 Silos	9 mrem	100 mrem/all pathways
Maximally exposed individual	10 mrem	100 mrem/all pathways

Miami River, and the direct radiation dose at the home nearest the K-65 Silos. (Dose from radon is excluded according to regulations.) The conservative assumptions used throughout the dose calculation process assure that the dose to the maximally exposed individual is the upper bound of the actual dose any member of the public receives.

Estimated Dose from Radon

The FMPC has been monitoring radon at both the FMPC fenceline and at background locations since the early 1980s, when advancing technology made possible continuous, passive environmental radon monitoring. In the past few years, the radon monitoring program has expanded both the number of locations and the number of detectors deployed at each location. In 1990, the number of locations used to determine the background radon concentration was doubled to four. (The background locations are air monitoring stations 15 and 16 and background locations 1 and 2.) Plans are underway to further increase the number in 1991. Also, during the second half of 1990 and in early 1991, real-time radon monitors were placed at the three air monitoring stations along Paddy's Run Road. Both of these changes should improve the quality of radon data obtained in 1991.

To be certain that the dose received from radon was not underestimated, the FMPC assumed that a person breathed the air at the fenceline continuously for an entire year. Radon decay products were assumed to be present in concentrations equal to one half the radon concentration, a condition referred to as *50% equilibrium*. For 1990, the estimated fenceline concentration was 0.23 ± 0.28 pCi/L above background, which is less than 8% of the DOE guideline. Using conservative lung-exposure factors to convert the measured concentration to dose, the effective dose for a radon concentration of 0.23 pCi/L was 69 mrem.[38]

The average fenceline radon concentration of 0.78 pCi/L is about 39% of the average indoor radon concentration reported for homes in the Cincinnati area. In that study, more than half of the 2,951 homes studied had radon concentrations above 2 pCi/L.[39] The estimated dose of 69 mrem above background can be compared to the national average dose of 200 mrem per year received from indoor concentrations of radon.

Significance of Estimated Radiation Doses for 1990

One method of evaluating the significance of the estimated doses is to compare them with doses received from background radiation (see Chapter Three). This background radiation yields approximately 200 mrem/year from radon and 100 mrem/year from other natural sources. Comparing the maximally exposed individual dose to the background dose demonstrates that even with the conservative estimates, the dose from the FMPC is much less than background without radon. If radon is included in both the estimated and background doses, the estimated dose is still less. Although the estimated dose will be received in addition to the background dose, this comparison provides a basis for evaluating the significance of the estimated doses. A dose that is small in comparison to that of background radiation will produce no measurable health effects.

Another method of determining the significance of the estimated doses is to compare them with dose limits developed to protect the public. The ICRP has recommended that members of the public receive no more than 100 mrem/year, and the DOE has incorporated this limit into Order 5400.5 as well.[13] All estimated doses from FMPC operations for 1990 were well within this limit.

Summary of Estimated Radiation Doses for 1990

Results of the dose estimate calculations indicated that the radiation dose from the FMPC to nearby residents was a small fraction of the background radiation dose a person receives each year from natural sources. The estimated dose to the maximally exposed individual was well below the DOE guideline of 100 mrem per year from all pathways.

The next chapter discusses the procedures and practices used at the FMPC to ensure that environmental monitoring data and the dose estimates based on the data are good representations of conditions at the FMPC.

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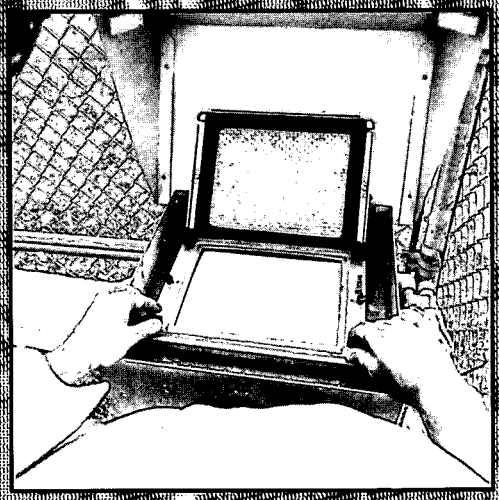
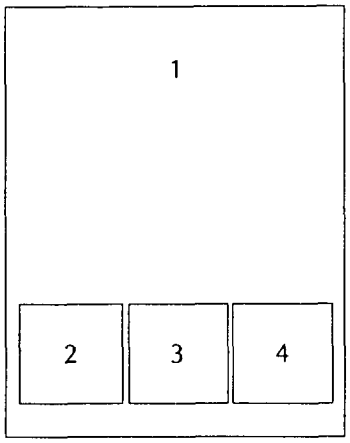
CHAPTER 8





1 – The Environmental Monitoring Program relies on accurate sampling and analysis, which can be assured by careful adherence to QA measures and procedures.

2 – Selecting an appropriate monitoring location is one of the many steps taken in assuring quality samples and data.

3 – Filters from air monitoring stations are carefully handled according to strict Quality Assurance requirements.

4 – Custody tape is used to seal samples to ensure proper handling after collection.

CHAPTER EIGHT

Quality Assurance for the Environmental Monitoring Program

Acquiring reliable data is essential to demonstrating compliance with environmental regulations and making valid conclusions concerning environmental conditions. In order to assure that reliable data are obtained, the FMPC has developed comprehensive procedures which contain detailed instructions for performing environmental monitoring activities in a controlled and consistent manner. These procedures comply with applicable USEPA requirements, such as NPDES regulations, and generally accepted practices for conducting environmental monitoring programs.

To further assure that monitoring data are reliable, Quality Assurance measures are included in all procedures. Quality Assurance measures are those actions and precautions taken to provide confidence that the resulting data are reliable. One example of a Quality Assurance measure is the packaging of air filters in individual plastic bags to prevent contamination during transfer between the laboratory and air monitoring stations. Another example is the analysis of Quality Assurance samples containing known concentrations of chemicals or radionuclides along with field samples to check the accuracy of the analysis being performed. The Environmental Monitoring section has in place a program for conducting regularly scheduled internal surveillances for assessing compliance to the Quality Assurance requirements included in EM procedures. In addition, the FMPC Quality Department independently checks the performance of environmental monitoring activities for conformance to the Quality Assurance requirements contained in procedures. This is accomplished through a system of planned audits, surveillances, and inspections.

Quality Assurance for the overall environmental monitoring program is discussed in the following sections under the two general topics of field activities and sample analyses.

Quality Assurance: Field Activities

In order to conduct reliable evaluations of environmental conditions, the following criteria must be met:

- Measurements made in the field must be accurately performed with instruments calibrated against known standards and according to accepted methods,
- Samples which are collected must be representative of actual conditions in the environment,
- Alterations of samples after collection must be prevented to the fullest extent possible until analyzed, and
- Results of field measurements and information pertinent to sample collection must be accurately recorded for subsequent evaluation and reference.

FMPC Environmental Monitoring (EM) procedures contain detailed Quality Assurance measures for meeting these criteria. These procedures specify step-by-step actions which must be followed when conducting EM field activities. Only trained personnel who have demonstrated proficiency in making field measurements and collecting representative samples are permitted to perform these functions.

QA measures for EM instrumentation include routine testing, maintenance, and calibration to help ensure proper operation and accurate field measurements.

The sample collection process is checked by taking duplicates at random of various types of environmental samples. Proper sample collection is indicated when the analysis results for the duplicate samples are within acceptable limits. A significant difference in the results is evidence that a sampling or analysis problem exists. In such cases, the cause of the difference is determined and corrective actions are initiated. Also, any data which are known to be unreliable are rejected.

The reliability of the water sampling collection process is also evaluated by means of trip, field, and equipment blanks. Trip and field blanks are prepared in the laboratory by filling some of the containers to be used for collecting samples with deionized water. Equipment blanks consist of deionized water which has been used as a final rinse of cleaned sampling equipment before it is reused for collecting samples. Any chemicals which will be added to the samples to preserve them after collection are also added to the blanks. Caps are then placed on the containers and the trip and equipment blanks are also sealed with tamper-evident tape. The blanks are transported along with the empty sample containers being taken by the sampling team into the field. The trip and equipment blanks

remain sealed and the field blanks are exposed to the air while samples are being collected. When sampling is complete, the blanks are submitted along with the field samples for laboratory analyses. The analytical results of the trip blanks detect any contamination of samples from empty sample containers and preservatives while results for the field blanks serve to determine if airborne contamination may have entered the field samples during the collection process. Results of equipment blanks provide data to evaluate whether or not sampling equipment was free of contamination before being used to collect samples.

Once samples are collected, precautions are taken to prevent alteration of sample constituents until the time of analysis. Such precautions are necessary to prevent changes which can occur in some samples (such as the conversion of nitrate to nitrite by microorganisms, the loss of volatile compounds with increasing temperature, or the loss of trace metals from solution by absorption on sample container walls). Refrigeration (or icing) and the addition of chemical preservatives (such as nitric or sulfuric acid) are used to decrease volatility of compounds, control biological and chemical changes, and maintain trace metals in solution.

Since no preservation technique can completely stabilize samples indefinitely, limits are placed on the holding time which may elapse from sample collection until analyses are completed. The USEPA specified sample preservation methods and maximum holding times are followed for samples collected and analyzed to demonstrate compliance with regulatory requirements such as the NPDES permit. Where applicable, the USEPA specified sample preservation and handling times are also applied to nonregulatory monitoring activities.

The handling of Environmental Monitoring samples from the time collected until delivered to the laboratory is controlled by Chain-Of-Custody (COC) procedures. All personnel relinquishing and receiving samples are required to sign, date, and note the time on a COC record. COC documentation is required for those samples collected to evaluate compliance with environmental regulations (such as NPDES regulations) so that the data generated from these samples are admissible as legal evidence. However, the custody of all other Environmental Monitoring samples is also controlled and documented according to the same COC procedures. This practice is done so that all EM data can be used as legal evidence, if necessary. Moreover, the application of COC requirements for all EM samples assures that such samples are only handled by well-trained and knowledgeable personnel.

Analytical Laboratory Quality Assurance

Quality Assurance is an integral part of the FMPC Analytical Laboratories' operations. Laboratory QA consists of a structured program of actions taken to help ensure that reliable results are obtained when analyzing environmental samples. Laboratory QA is designed to:

- Certify that analytical methodologies comply with USEPA protocol,
- Evaluate analytical performance systematically and objectively,
- Identify problems so that they can be promptly corrected, and
- Detect and prevent the use of questionable data.

Day-to-day evaluation of the performance of FMPC laboratories is accomplished by means of Quality Assurance samples. Quality Assurance samples include National Institute of Standards and Technology reference materials, USEPA radionuclide solutions, compounds of precisely known purity, standardized reference solutions, duplicate field samples, and field samples to which known amounts of contaminates have been added.

The Operations Department Analytical Laboratories' Sample and Data Management group prepares the QA samples and submits them to the various onsite laboratories for analysis. At least 10% of the total number of samples analyzed are Quality Assurance samples which are processed along with the field samples.

The FMPC Quality Department evaluates the QA sample results and regularly submits reports to the laboratories for use in identifying potential areas of concern. If a significant problem is indicated, the Quality Department notifies the laboratories so that corrective actions can be taken and suspect results for field samples can be evaluated and rejected if warranted. In addition to analyzing Quality Assurance samples, the individual laboratories perform daily instrument calibrations and stability checks and routinely analyze reagent blanks along with the field samples.

Independent Evaluations of FMPC Laboratories

As described above, a comprehensive QA program is conducted by the FMPC Analytical Laboratories in conjunction with the Quality Department to help ensure that reliable results are obtained for environmental samples analyzed by onsite laboratories. In addition to this internal QA program, the FMPC laboratories regularly take part in several external QA programs conducted by outside organizations. Participation in external QA programs is a means of independently evaluating FMPC laboratory performance and provides added confidence that reliable results are being obtained for environmental samples.

External QA evaluations are conducted in the following manner. The organization conducting the evaluation prepares QA samples containing known amounts of a chemical or radioactive species. The known, or "true," amount of the species may be established by adding a precisely measured amount of the species to a substance which does not contain any of the species. For example, a QA water sample for fluoride analysis may be prepared by adding an accurately weighed amount of sodium fluoride to pure, deionized water. The true amount of the species may also be established by multiple analyses of an environmental material by one or more laboratories which have demonstrated the ability to perform accurate determinations. The true amount of background uranium contained in a soil sample used for QA checks is determined in this manner.

The QA samples, but not the known values of the test species, are distributed to the participating laboratories which analyze them and return the results obtained. The organization administering the program then provides a performance evaluation report comparing the laboratory's results to the true values of the test species. In most cases, the report also contains a comparison of the results obtained by the other participating laboratories. These comparisons show whether the laboratory's analyses are within acceptable limits of accuracy, or if improvements are required.

One external QA program in which the FMPC participates is administered by DOE's Environmental Measurements Laboratory (EML). This program is conducted to evaluate the performance of laboratories which perform analyses to measure radionuclides in environmental samples. In this program, the FMPC receives and analyzes water, air filter, and soil samples for uranium and submits results for comparison to the results obtained by EML. In making the comparison, a ratio was computed by dividing the FMPC result by the EML result for each sample. The ratio would be 1.00 if the results agreed exactly.

The ratios for samples analyzed during 1990 are listed in Table 25.[40, 41] FMPC and EML results for the determination of uranium in two water samples were in excellent agreement since the ratios were 1.02 and 1.12 for the values obtained by each laboratory.

The FMPC and EML results for the 90-03 Quality Assurance soil sample were in perfect agreement since the ratio of the two results was 1.00. The FMPC value for the 90-09 soil sample was 21% lower than the EML value. It is not uncommon for the results obtained by two reliable laboratories analyzing the same soil sample for uranium at the parts per million level to differ by as much as 25%. Consequently, the 21% difference between the FMPC and EML values for the 90-09 soil sample is not

excessive and the agreement between the two laboratories for this sample is acceptable.

For the 1990 air filter samples, the ratios of the FMPC values to the EML reference value were consistently above 1.00 and ranged from 1.17 to 1.52. This indicates that the FMPC may have been overestimating the amount of uranium in 1990 environmental air samples.

Another external QA program in which the FMPC participates is the Discharge Monitoring Report (DMR) QA evaluations. This program evaluates the ability of laboratories to measure nonradioactive contaminants in wastewater.

All laboratories which perform NPDES permit wastewater analyses are required to participate in the DMR QA program. Since NPDES samples are analyzed in-house, FMPC laboratories are included in this program. As stipulated by the USEPA, a corresponding QA sample must be analyzed for each parameter listed in the NPDES permit. The NPDES permit parameters which are measured by FMPC laboratories are discussed in Chapter Five under NPDES Compliance Summary for 1990. The USEPA evaluates the results for the QA samples only as satisfactory or unsatisfactory.

Results obtained by the FMPC laboratories for the 1990 DMR QA samples are summarized in Table 26. The result obtained for iron was higher than the upper limit of results considered acceptable by the USEPA. The FMPC was issued a new NPDES permit on February 12, 1990, which does not require the monitoring or reporting of the concentration of iron in liquid effluents. Consequently, the FMPC discontinued analyzing NPDES samples for iron as of March 1990.

Except for iron, all other FMPC results submitted during 1990 for DMR QA were assessed as satisfactory by the USEPA. The DMR QA evaluations of the performance of FMPC laboratories began in 1985. In addition to the 1990 iron result, only one other analysis, a biological oxygen demand determination in 1985, was unacceptable during the six years the FMPC has participated in this external QA program.

The FMPC laboratories also participate in the Proficiency Environmental Testing (PET) external QA program. This is a voluntary program administered by a commercial vendor of analytical laboratory Quality Assurance services, and each laboratory pays a fee to participate. Periodically the FMPC Sample and Data Management group submits PET samples to the various onsite laboratories which analyze them concurrently with field samples. Results obtained for the QA samples are compiled by the SD&M section and submitted for evaluation. A monthly evaluation

report is then provided by the vendor comparing the FMPC laboratories' results to the reference values for each sample and to the results obtained by other laboratories participating in the PET program.

A summary of the performance of FMPC laboratories in the PET QA program during 1990 is provided in Table 27. For 25 of the 28 parameters analyzed, 92% to 100% of the results were within the USEPA acceptable criteria. Overall, 97% of the 364 determinations performed met these criteria. The use of this commercial service provides FMPC laboratories an additional resource for evaluating their performance so that any problems or errors can be detected and eliminated.

To further enhance the QA Program, the FMPC continued a split water sampling program with the Ohio Department of Health (ODH) which began in 1987. In many multilaboratory water analysis QA programs, the test samples are prepared in a laboratory rather than collecting them from the environment. The FMPC-ODH split sample program provides a means for comparing results obtained for samples actually collected in the field. To obtain split water samples, FMPC and ODH sampling team members alternately add a portion of the sample being collected to their individual sample bottles until the bottles are full. This collection method helps ensure that both water samples are as identical as possible. Split samples of surface and groundwater collected in this manner are submitted to the FMPC and ODH laboratories for analysis of uranium.

The FMPC did not receive the ODH results for samples collected during 1989 in time to be included in the 1989 AER, so they are presented in this report. In fact, the December 1989 results were still not available in time to be included in this report. The January through November 1989 results are listed in Table 28. The 1990 results from ODH should be included in the 1991 AER. In comparing uranium results obtained by both laboratories, the ± uncertainty term provided with each result is taken into account. A range for each individual result is calculated by adding and subtracting the uncertainty term reported with the result. If the FMPC and ODH result-range for an analysis overlap, the two laboratory results are equivalent. Results obtained by both laboratories for the determination of uranium agreed very well since 94.3% of the results reported for these analyses were equivalent. This indicates very good agreement between the laboratories considering that the samples were actual field samples rather than laboratory-prepared QA samples.

Contract Laboratory Quality Assurance

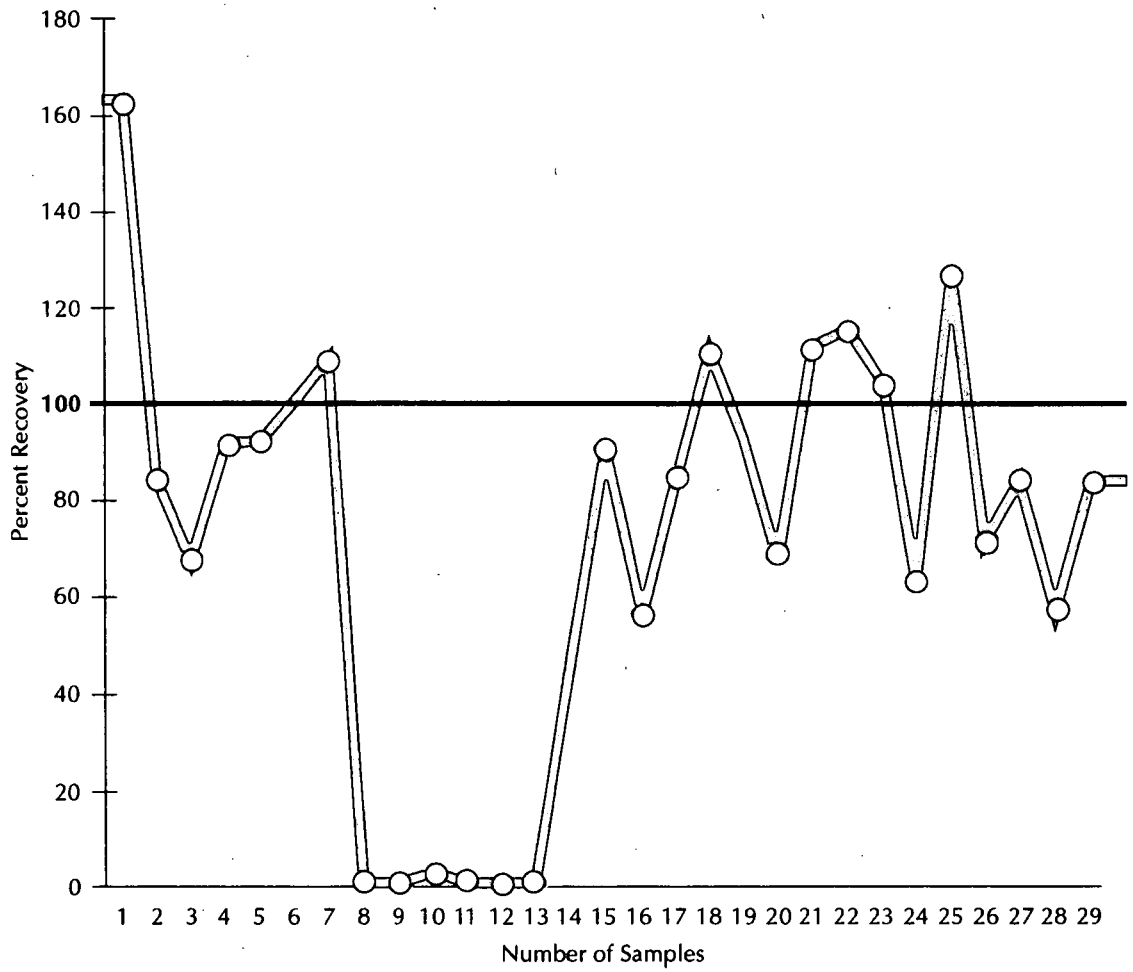
Because of the great number of analyses required to support all the various environmental monitoring activities, the FMPC uses commercial laboratories to supplement its onsite analytical resources. Commercial laboratories must meet stringent requirements before being selected to provide environmental analytical services. To select the best qualified laboratory, a review of various QA specifications is conducted including personnel qualifications, analytical procedures, sample handling and preservation, data evaluation and record keeping, and requirements for precision, accuracy, and minimum detectable levels. Results obtained in independent QA programs are also reviewed as part of the evaluation of each candidate laboratory's analytical capabilities. Onsite audits of the laboratories' facilities and operations are then conducted by FMPC laboratory, procurement, and QA personnel before final selections are made. After selecting the laboratories, QA samples are submitted regularly with field samples in order to evaluate their performance on a continuing basis.

As part of the ongoing activities for evaluating the performance of contractor laboratories, the FMPC regularly sends QA samples along with field samples to the laboratory which analyzes offsite air filter samples. Twenty-nine QA air filter samples, prepared with amounts of uranium known only to FMPC, were submitted to the laboratory with 1990 field samples. The known amounts of uranium on the QA air filters were in the range of the amounts normally present on field samples.

The contract laboratory's percentage of recovery of uranium for 22 of the 29 QA air filter samples ranged from 57% to 164% and averaged 93% (Figure 49). This performance is considered adequate for the determination of the very low levels of uranium present in offsite air filter samples. In contrast, results reported by the contractor laboratory for seven of the QA samples indicated recoveries of less than 5%. These seven QA samples were submitted with offsite air filter samples collected during the second quarter of the year.

The FMPC and the contract laboratory were not able to identify a cause for the apparent low recoveries. However, it was concluded that the uranium results reported by the contract laboratory for the second quarter were acceptable for several reasons. First, the uranium results for these samples were consistent with the results obtained for all other 1990 offsite air filter samples during those times when the QA sample results indicated satisfactory performance by the contractor laboratory. Second, since the airborne uranium concentrations measured at the fenceline air monitoring stations were normal and consistent throughout the year, the concentrations at the offsite stations would likewise be expected to be consistent for the entire year. Third, the low recoveries for the seven QA

FIGURE 49: Air Filter/Uranium QA Samples, 1990

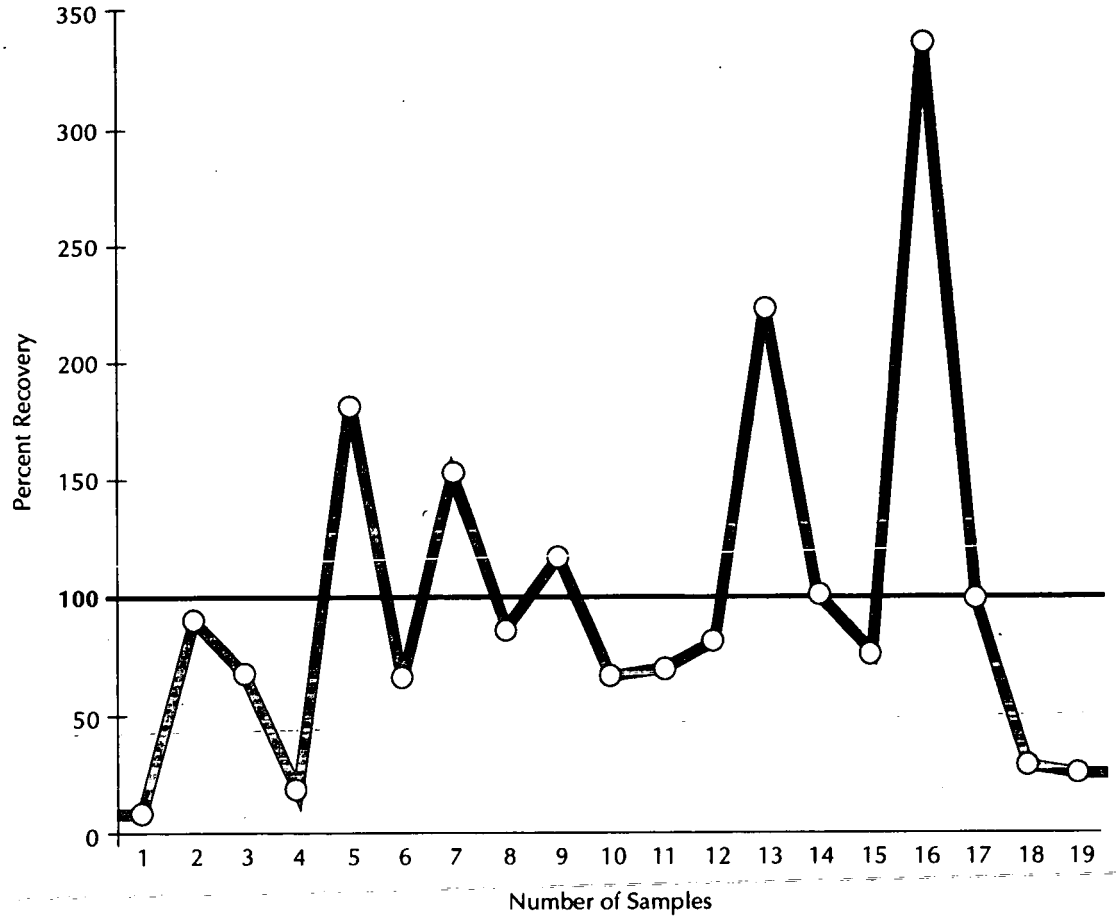


air filter samples could very likely have been caused by errors in preparing those QA samples and would not have been the result of problems during analysis of the offsite air filters.

The FMPC employed the same Quality Assurance measures to evaluate the contractor laboratory's analysis of uranium in milk samples. Figure 50 shows the percentage of recovery for the 19 QA milk samples analyzed with the FMPC 1990 field samples.

The contract laboratory's percentage of uranium recovery for 11 of the 19 QA milk samples ranged from 65% to 118%, and recovery percentage averaged 85%, indicating acceptable performance for this difficult analysis. However, recoveries for the seven other QA samples were as low as 9% and as high as 340%. These extreme QA sample recoveries

FIGURE 50: Milk/Uranium QA Samples, 1990



indicate that 1990 uranium in milk results for some samples from both local and background dairies were unreliable.

Unreliable analysis results were likely caused by delays at the contract laboratory. The lab had accumulated a significant backlog of all types of samples — including milk samples — from both the FMPC and other facilities, significantly delaying processing. As a result, the contract laboratory stored samples for much longer than normal before they could analyze them. This extended storage time causes separation of the liquid and solid components of the milk, making it very difficult to obtain homogenous fractions of the samples for analysis. The uranium results for such nonhomogenous sample fractions could be either higher or lower than the correct value.

In response to the poor QA performance and the inconsistent results of the milk sampling program, the FMPC is using milk collection containers which are certified to be free of uranium contamination. Additionally, methods for improving the milk collection, preservation, and storage before analysis are being investigated. As discussed in Chapter Four, the positive uranium results reported for some 1990 milk samples from the local dairy were not caused by FMPC uranium releases, but rather reflect problems which occurred in sampling or analysis.

Summary of Quality Assurance Activities

The acquisition of reliable data for environmental monitoring is a comprehensive program. Appropriate sampling procedures must be followed and proper analytical procedures practiced; data must be examined, validated, and presented in meaningful form; and results must be properly reported. The overall performance of the contract and FMPC laboratories, as determined by internal and external QA programs, was of a level which ensured that reliable monitoring data were obtained for determining compliance with environmental regulations and for making valid evaluations of environmental conditions. The next chapter describes the waste management activities at the FMPC.

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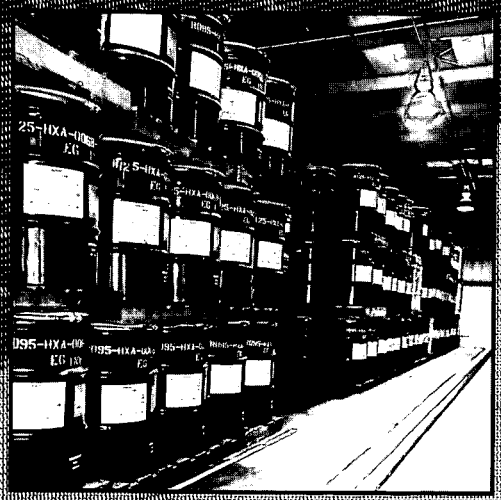
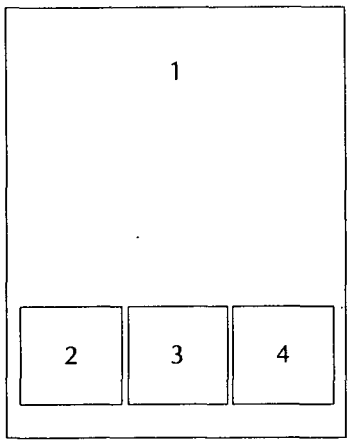
CHAPTER 9





1 – Easy-to-construct fabric structures are now being used to shelter some drums previously stored on open pads.

2 – The FMPC ships baled scrap metal offsite for disposal.

3 – Storage of drums containing waste is regulated and enforced to allow for easy inspection.

4 – The repackaging of thorium into new drums is one of the major safety-related projects at the FMPC.

CHAPTER NINE

Waste Management Activities

Even though production activities at the site have ended, the FMPC's waste management program continues to grow as a key element in preventing the release of pollutants into surface water, groundwater, air, and the surrounding soil and sediments. Indeed, as FMPC environmental cleanup activities proceed, contaminated soil, old building materials, used protective clothing, and other wastes will be generated in significant amounts.

The objective of the FMPC's Waste Management Program is to dispose of, treat, or safely store radioactive, hazardous, and conventional wastes while complying with all applicable regulations. In addition to managing wastes generated by the ongoing cleanup efforts, the program is also responsible for *backlog wastes* generated after the waste pits were closed but before offsite waste disposal shipments began. These backlog wastes include those generated by the utility, maintenance, and administrative services and by chemical and metallurgical processes during the years of production.

The FMPC uses the most recent advances in waste management technology to identify, treat, store, and ultimately dispose of the waste in order to comply with federal and state regulations, particularly the Resource Conservation and Recovery Act and DOE orders. The FMPC's strategy for meeting these objectives consists of:

- Pursuing a waste minimization program,
- Shipping as much waste offsite as possible,
- Maintaining and upgrading storage facilities for waste that cannot be disposed of or eliminated, and
- Developing and implementing programs to reduce disposal costs.

This chapter highlights 1990 FMPC activities related to management of wastes within the production and administration areas of the site. The next chapter, Remedial Investigation and Feasibility Study, describes the management of the wastes from past activities which are stored in pits, silos, and landfills at the FMPC.

Categories of Waste at the FMPC

The wastes generated and stored at the FMPC can be grouped into three general categories: low-level radioactive waste, hazardous or mixed waste, and conventional industrial waste. Examples of each of these types of waste are listed below:

Low-Level Radioactive Waste

- Process residues (slags, neutralized raffinates, sump sludges),
- Construction rubble,
- Thorium materials,
- Sediments from the Stormwater Retention Basin and the Biodenitrification Surge Lagoon,
- Scrap wood (pallets),
- Scrap metal (baled drums, process equipment, pipe), and
- Spent lime sludge from water treatment plant.

Conventional Industrial Waste

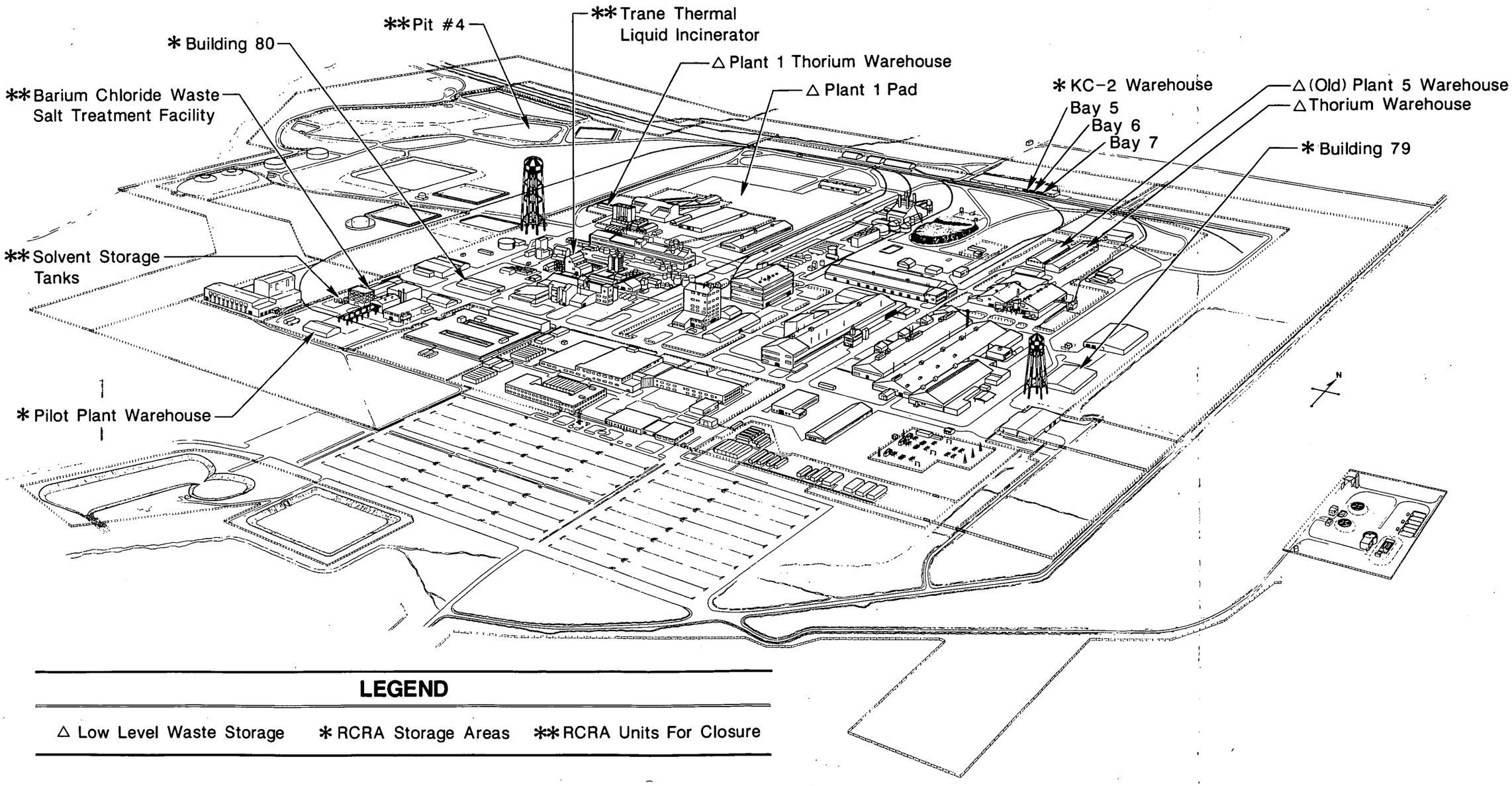
- Nonprocess trash from the administration area,
- Boiler Plant fly ash, and
- Noncontaminated construction rubble.

Hazardous or Mixed Waste

- Contaminated cutting and cooling oils,
- Solvent still-bottoms and sludges,
- Barium Chloride salts,
- PCB-containing materials,
- Xylene,
- Tributyl phosphate/kerosene,
- Spent solvents,
- Materials used to clean spills of waste covered under RCRA, and
- Material containing lead, such as residue from sand blasting operations.

The FMPC facilities and areas within which these wastes are managed and stored are shown in Figure 51.

FIGURE 51:
FMPC Waste Management Areas



LEGEND

△ Low Level Waste Storage * RCRA Storage Areas ** RCRA Units For Closure

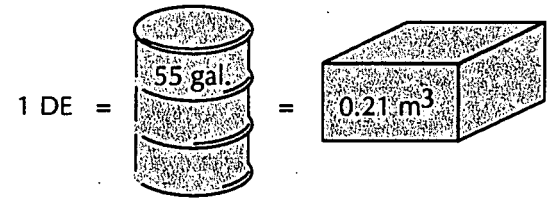
1302

Low-Level Radioactive Waste Management

Low-level radioactive wastes (LLW) are those materials contaminated with radionuclides, such as uranium, at concentrations which are not economically feasible to recover. During 1990, there were more than 122,100 drum equivalents of low-level radioactive waste stored onsite, exclusive of the scrap metal piles and the pit and silo wastes discussed in Chapter Ten.

FIGURE 52: Drum Equivalents

In order to consistently track and report the quantities of low-level radioactive waste being generated and disposed, the FMPC has adopted a uniform unit of measure — the "drum equivalent." This is defined as the number of 55-gallon drums that it would take to contain a given volume of waste. One drum equivalent (DE) is equal to the volume of a single 55-gallon drum which is 0.21 m^3 (7.4 cubic feet). A unit based on drum volume was adopted since most packaged wastes at the site are stored in drums, and drums are a common unit used for shipping waste offsite for disposal.



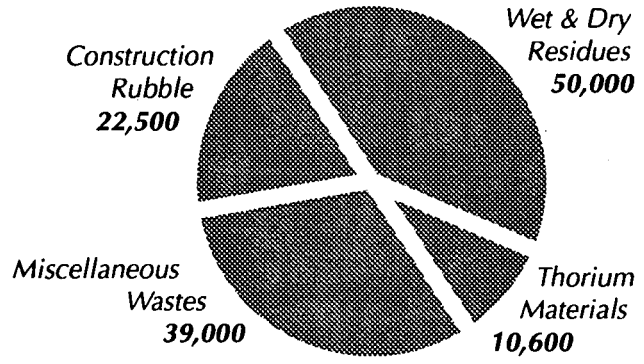
This report will use "Drum Equivalent" as a unit of measure whenever possible.

Storing Low-Level Wastes

Because the low-level radioactive wastes and uranium residues are no longer going into onsite disposal pits or being processed to recover uranium, they are stored outside in drums until the FMPC ships them to the Nevada Test Site (NTS). Some of these drums and other containers have corroded and possibly leaked. To prevent further deterioration and potential releases of contaminants, the FMPC began a major program to improve storage conditions in 1989 and continued it through 1990. These improvements included redrumming wastes, overpacking old drums, and storing drums in the now-idle production buildings. Over 28,000 drums have been overpacked into new containers, and more than 23,000 drums have been moved from outdoor pads to covered storage areas. In addition, the FMPC rebuilt storage pads, established minimum spacing requirements for drums, improved temporary diking, and increased inspections to detect problems as they develop. About 40,000 drums remained outdoors at the end of 1990.

In an effort to provide even better temporary storage for the backlog of wastes awaiting shipment to NTS for disposal, a 560 m^2 (6,000 ft^2) temporary fabric structure was erected on the Plant 1 Pad. The FMPC stored 1,250 drums of waste in the first of these fabric structures; once it was determined that the structure was suitable for such storage, the FMPC began planning to add enough fabric structures to provide indoor storage for the remainder of drums stored onsite. Such structures cost much less than permanent buildings because they can be built quickly while generating much less waste both during construction and eventual demolition. All told, the FMPC has improved storage conditions for and conducted rigorous inspections of more than 60,000 drums of low-level radioactive waste and residues. Backlog waste totals are presented in Figure 53.

FIGURE 53: FMPC Backlog Waste, 1990



Total = 122,100 drum equivalents

Disposing of Low-Level Radioactive Wastes

The low-level radioactive wastes generated at the FMPC are regulated under the Atomic Energy Act and can be disposed of only in designated radioactive waste disposal facilities. The principal disposal site for FMPC radioactive wastes is the Nevada Test Site. The FMPC has shipped over 200,000 DEs of LLW from the site since waste shipments began in 1985.

In April 1990, NTS instituted new audit requirements of all waste generator sites, including the FMPC. The FMPC could not ship any waste to NTS during May through August while FMPC's permit renewal was being approved by NTS. In September, NTS granted the FMPC approval to resume shipping, and a total of 25,749 DEs of low-level radioactive waste was shipped during 1990. At the end of 1990, the FMPC was the only DOE waste generator site which had NTS approval to resume shipments of waste.

The greatest volume of low-level radioactive wastes generated at the FMPC in the past has been residues and by-products from the uranium

Low-Level Waste Shipment Data, 1990

Material Description	Drum Equivalents
Scrap Wood	3,338
Baled Trash	3,653
Refuse Metal	7,227
Construction Rubble	11,346
Rubber	185
TOTAL	**25,749**

production process. These wastes are in the form of sludges, filter cakes, slags, dust collector residues, and uranium metal chips or turnings from machining operations. Although the end of production eliminated new contaminated process residues, current waste management, maintenance, and cleanup operations continue to generate contaminated sludges and other wastes.

Another source of LLW is spent lime from the water processing plant. The FMPC produces its own drinking water and process water from three onsite wells. The water treatment process includes a lime-softening step. The spent lime from this process is collected in sludge beds on the western side of the site, and these beds are nearly full. Options are being studied to address this problem.

Other low-level wastes include items once used in the production process which have become contaminated with uranium and cannot be decontaminated or used again. These items include metal drums, wooden pallets, and trash such as rags, paper, and wood. Most of the wastes now generated are from cleanup and other environmental restoration activities and renovation projects.

Scrap Metal Activities

If scrap metal is uncontaminated and potentially usable, it is stockpiled for shipment to local scrap dealers or for use elsewhere at the site. Contaminated scrap metal that cannot be used again is packaged and shipped offsite for disposal.

During 1990, about 441 metric tons (486 tons) of scrap metal was decontaminated to levels suitable for unrestricted release. Sales of the decontaminated metal recouped $30,000 of the decontamination costs.

The FMPC is also storing about 1,225 metric tons (1,350 tons) of scrap copper on a concrete pad in the northwest part of the site. The copper scrap, consisting mostly of motor windings but possibly containing asbestos insulation, was transferred to the FMPC as a result of an upgrade of other DOE facilities during the 1970s.

Managing Thorium at the FMPC

Since the early 1970s, the FMPC has served as the federal government's storage site for thorium, a naturally occurring radioactive element. Even before its designation as the federal repository, the FMPC studied possible uses for thorium, and had processed the material for use at other government facilities. All thorium processing at the FMPC ended in 1979. There are about 1,100 metric tons (1,200 tons) of thorium stored in steel drums and other containers on the plant site. About two-thirds of this material was processed onsite, with the remaining portion delivered from other DOE facilities.

The FMPC is carefully managing the thorium to reduce the potential radiation hazard to employees, local residents and the environment. For example, everyone entering thorium storage areas must obtain a radiation work permit which lists the specific safety requirements and additional guidelines that must be observed while in the area. The FMPC is taking steps to improve how it stores thorium and is awaiting the government's decision on the final storage location of the thorium materials.

The thorium stored at the FMPC consists of various materials, principally thorium oxides (generally a fine powder), processing residues in a variety of forms, and a small quantity of thorium metal. The Plant 8 silo and bins had contained about 175 metric tons (190 tons) of bulk thorium oxide materials, plus inert materials like diatomaceous earth. This material is now safely packaged in new, double containers and is stored onsite. About 9 metric tons (9.9 tons) of thorium nitrate solution is stored in Pilot Plant Tank 2. The majority of the remaining thorium, about 13,300 containers (containers vary in size from 55 gallon drums to drums as small as one gallon), is stored in warehouses (Buildings 64, 65, 67, and 68 in Figure 51).

The FMPC has developed a comprehensive three-project plan for improving the temporary storage conditions for the thorium inventory. All of the thorium materials will be identified, inventoried, and repackaged or overpacked in the course of the project.

The first project, completed in March 1989, addressed the bulk thorium materials in the Plant 8 silo and bins. As the bulk thorium was removed from the silo and bins, it was placed in double-containment drums called overpacks (a 48-gallon drum is packaged inside a 55-gallon drum), inventoried and monitored. The drums were then stored in an onsite warehouse located along the northern edge of the production area, away from daily plant operations. The silo and bins were then decontaminated and demolished.

The second project was the overpacking of the 241 containers (212 of the containers were drums) stored outdoors. A remote system to handle, identify, and overpack the 241 thorium drums and containers was designed. Each container was inventoried, weighed, and overpacked, then placed in temporary storage at the FMPC. This thorium repackaging project was completed in March 1990.

The third project, overpacking 13,000 drums of thorium stored in Buildings 64, 65, 67, and 68, will begin later in 1991.

By completing two of these projects, the FMPC has significantly reduced the potential for any accidental release of thorium through a structural failure or a deteriorating container. The new overpack containers will also protect the thorium materials from the weather and greatly reduce the possibility of any thorium being released to the environment. By removing the Plant 8 silo and bins and storing the thorium farther from daily operations, exposures from the thorium to employees working in the production area will be kept to a minimum.

Conventional Industrial Waste Management

The FMPC also generates nonradioactive wastes normally associated with a large industrial facility, such as its boiler plant waste and nonprocess trash from the administrative areas.

The Boiler Plant produces fly ash, sludges from boiler water treatment, and runoff from the coal pile. Fly ash is taken to the southwest corner of the site and placed on an above-ground pile. The boiler plant water sludges and coal pile runoff are currently drained to a retention pond, and from there the water goes to the General Sump for treatment.

Paper waste, packaging materials, cafeteria waste, and other noncontaminated wastes generated in the administrative areas outside of the former production area of the site are collected in dumpsters free from radioactive contamination and are sent to a local commercial sanitary landfill for offsite disposal.

Mixed Waste Management

The third major category of waste at the FMPC is mixed radioactive/hazardous waste, referred to as mixed waste. These wastes are regulated under the Atomic Energy Act as well as RCRA. The latter was passed in 1976, along with subsequent amendments in the 1980s, to address a problem of enormous magnitude — how to safely dispose of the huge

volumes of municipal and hazardous waste generated nationwide. The goals set by RCRA are:

- To protect human health and the environment,
- To reduce waste and conserve energy and natural resources, and
- To reduce or eliminate the generation of hazardous waste as expeditiously as possible.

RCRA Permit Applications

In September 1988, the USEPA published a clarification notice for facilities that treat, store, or dispose of mixed waste. These rules allowed owners and operators of facilities handling mixed wastes to submit a RCRA Part A Permit Application to the USEPA by March 1989 in order to continue to operate a hazardous waste facility until a final permit was issued. The FMPC had this interim status with the State of Ohio during 1990. Because the FMPC has a large amount of radioactive wastes that may contain various RCRA-regulated constituents due to past processing operations, the FMPC submitted a revised RCRA Part A Permit Application to the USEPA and OEPA on March 22, 1989. This modified application significantly increased the variety of waste streams regulated by RCRA. In addition to listing FMPC waste streams and waste management units, the application also defined current and planned storage facilities needed to safely store these wastes at the FMPC.

An extensive revision of the FMPC's RCRA Part B Permit Application was also completed and submitted in September 1989. A RCRA Part B Application is the detailed description of how a facility will comply with specific hazardous waste management requirements set forth in the federal regulations.[42, 43] Upon final approval, the Part B Permit Application becomes the actual operating permit for a facility. The original FMPC Part B Permit Application was submitted in 1985, and some sections have been revised during the past four years. However, in order to comply with the new requirements for mixed wastes and maintain interim status, the FMPC revised the entire Part B Permit Application. An 11-volume document detailing the site's RCRA waste management program was submitted to the USEPA and OEPA. The new Part B application accomplishes several goals:

- It details information from the Part A application,
- It updates the FMPC's waste analysis plan for mixed wastes,
- It details the site's Remedial Investigation/ Feasibility Studies for hazardous waste management units including groundwater monitoring programs, and
- It includes a RCRA Contingency Plan for hazardous waste emergencies.

RCRA Contingency Plan

A RCRA Contingency Plan was submitted as part of the Part B Permit Application to ensure that specific planned procedures exist for hazardous waste handling and storage at the FMPC, in the event that an emergency occurs. Previously, the FMPC had used the FMPC Spill Prevention Control and Countermeasures Plan (SPCC) and the FMPC Emergency Plan to meet the emergency planning requirements of RCRA. The current RCRA Contingency Plan is designed to reduce hazards to people and the environment from fires, explosions, or any unplanned release of hazardous waste at the FMPC. It establishes policies, procedures, and countermeasures to prevent accidents and minimize adverse effects from an emergency situation. The RCRA Contingency Plan was prepared and distributed in September 1989 to both the USEPA and OEPA, to all FMPC site organizations, and to outside organizations having emergency mutual aid agreements with the FMPC. The plan was modified during 1990.

Performing RCRA Closures

If buildings or equipment contaminated with RCRA constituents are to be used again, rather than simply removed from service, they must be cleaned to more stringent standards as specified by the OEPA. This is known as a RCRA closure. The plans detailing tasks and schedules needed to decontaminate these areas are known as RCRA closure plans. The following paragraphs describe the RCRA closure plans that the FMPC has completed or submitted to OEPA for their approval.

The Barium Chloride Waste Salt Treatment Facility operated from December 1985 through March 1986 as a pilot-scale operation to convert water-soluble barium chloride to water-insoluble barium sulfate. Located inside the Pilot Plant, this facility included four stainless steel tanks (Figure 51). About 8,400 kg (18,500 pounds) of barium chloride were treated.

For this RCRA closure, the equipment and piping were decontaminated and removed from the building.[44] Since the floor of this facility may be used as a storage space, the OEPA established additional cleanup requirements.[45] One of the requirements was that deionized water be poured over the floor and then sampled for RCRA constituents. The data were compared to OEPA established limits which were 100 times more stringent than the RCRA EP Toxicity standards; none exceeded the standards. This project was completed in February 1990.

The Trane Thermal Liquid Incinerator is located in Building 39B and surrounding areas (Figure 51). This incinerator, which operated periodi-

cally between 1980 and 1986, burned waste oils generated at the FMPC. The burn rate for the incinerator was about 26 liters (7 gallons) per hour. Although it is not known what types of oil were burned in the incinerator, oils that were stored next to the incinerator were analyzed and found to include lead and 1,1,1-trichloroethane, both of which are RCRA hazardous wastes. The FMPC revised this closure plan by adding equipment to be decontaminated and submitted the plan to OEPA for their approval.

The Storage Pad North of Plant 6 held drums of residues and oily sludge created during Plant 6 wastewater treatment. (Plant 6 was built in 1952, and operations through the years included chemically treating, machining, and inspecting uranium-metal products — see Figure 51.) The wastes stored here were considered hazardous because of the possible presence of 1,1,1-trichloroethane and lead which were present in the Plant 6 processes. The FMPC identified the Plant 6 pad as a hazardous waste storage unit in the September 1989 RCRA Part A permit application. The pad must be decontaminated and cleaned because it is no longer in use. A closure plan has been submitted to OEPA for their approval.

Bulk Storage Tanks T-5 and T-6 are located in a diked tank storage area west of the Pilot Plant. They contained thorium nitrate solutions from 1969 until about 1980. It is believed that the tanks were empty from 1980 until April 1984. At that time, the tanks were used to store mixed solvent wastes until the tanks were drained in 1989. A closure plan has been submitted to OEPA for their approval.

Tank 5 is an underground storage tank, installed in 1954 and used through 1986. It is located near Building 31, which is a vehicle maintenance garage for the site (Figure 51). Waste oils were collected in the floor drains, where the oils were separated from the water; the water flowed to a sanitary sewer while the oils were directed to Tank 5. These wastes varied over the years, and included hydraulic oil, motor oil, gasoline, diesel fuel, and cleaning solvents such as 1,1,1-trichloroethane. A closure plan has been submitted to OEPA for their approval. Tank 5 is included in the list of underground storage tanks in the next section.

Underground Storage Tank Investigation

The Underground Storage Tank program made significant progress during 1990 at the FMPC. Ten of the original 13 tanks registered with the Ohio State Fire Marshal were removed from the ground. The FMPC was required to perform these tasks under state regulations since these tanks were permanently out-of-service.

During 1990, two tanks were removed from the list. Tank 5 was found to contain RCRA-regulated hazardous wastes; therefore it was reclassified as a hazardous waste management unit and subject to OEPA regulations as described in the previous section. The existence of Tank 4, which was indicated in historical documents, was never confirmed. After a thorough investigation, it was removed from the list of registered tanks.

Of the 11 remaining registered tanks, only Tank 3 was in service at the beginning of 1990. In early June, the FMPC was preparing to perform a required tightness test on Tank 3 in the presence of an inspector from the fire marshal's office. While excavating soils above the tank, petroleum-contaminated soils were found. The discovery was reported, and the tank was taken out of service. A decision was made to remove the tank from the ground in conjunction with the scheduled removal of nine other tanks.

In April 1990, evidence of another underground storage tank was discovered in a records search which was initiated for a different reason. This tank, unaccounted for in recent years, is referred to as Tank 17. It is a 200-gallon steel tank which held waste oil from an oil/water separator located under the floor of Building 46. The tank was located under the pavement just north of the building. The tank was pumped and isolated by disconnecting the lines and capping the ports. The FMPC took

Underground Storage Tanks, 1990

Tank Number	Capacity (Gallons)	Product Stored	Construction	Age (Years)	Location	Regulation Applicability	Date Removed
1	1,500	Gasoline	Fiberglass	8	Building 31	UST	9–16–90
2	1,500	Gasoline	Fiberglass	8	Building 31	UST	9–16–90
3	12,250	Diesel Fuel	Steel	36	Building 24B	UST	10–19–90
4	3,000	Gasoline	Steel	36	Plant 1 Truck Door	UST	—
5	200	Waste Oil	Steel	36	Building 31	RCRA	—
6	1,000	Gasoline	Steel	36	Building 12	UST	9–25–90
8	1,000	Gasoline	Steel	36	Building 31	UST	9–21–90
9	1,000	Gasoline	Steel	36	Building 31	UST	9–19–90
10	3,000	Gasoline	Steel	36	Building 31	UST	9–16–90
11	3,000	Kerosene	Steel	36	Plant 1 Truck Door	UST	9–14–90
12	2,000	Gasoline	Steel	36	Plant 1 Truck Door	UST	9–14–90
13	3,000	Gasoline	Steel	36	Plant 1 Truck Door	UST	9–17–90
14	3,000	Soluble Oil	Steel	26	Plant 6	UST	—
17	200	Waste Oil	Steel	36	Building 46	To be determined	—

samples of the tank contents, the water which had accumulated within the separator pit, the surrounding soils, and the water which had accumulated within the excavation. Results of the sampling confirmed a release of petroleum to the soils; one sample indicated the presence of 1,1,1-trichloroethane in the water from the separator pit. The FMPC must determine the regulatory status (RCRA or UST) of the tank before further actions are taken.

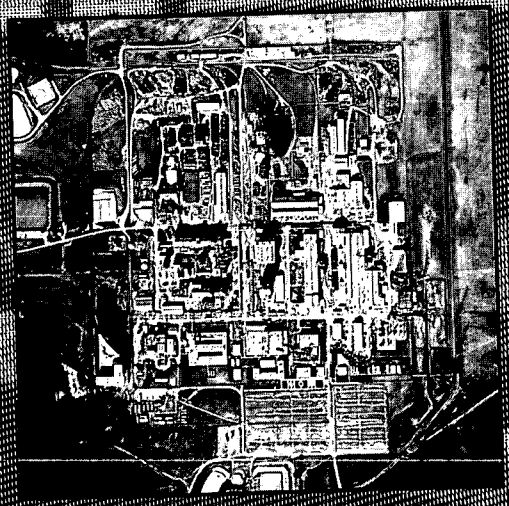
The FMPC removed ten of the tank systems during 1990. To accomplish this, seven excavations were necessary at four locations within the plant area. After the tank systems were removed, the FMPC sampled soil and groundwater at each of these excavations according to the state fire marshal regulations. Results of this sampling, which were received at year's end, confirmed petroleum releases at all seven excavations. Characterization of the petroleum releases sites should begin in 1991.

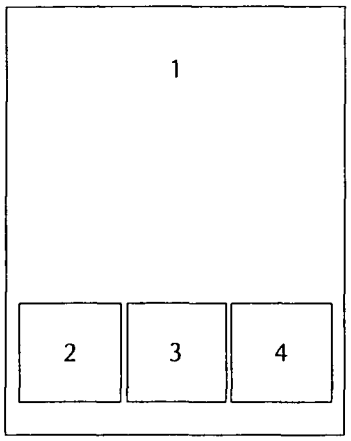
Summary of Waste Management Activities

The FMPC continued to make significant progress in shipping waste offsite and in improving the storage and management of those wastes remaining onsite. In addition, the FMPC has renewed its emphasis on complying with RCRA waste regulations. Actions discussed in this chapter have reduced the potential for environmental problems related to waste management activities. The next chapter on the Remedial Investigation/Feasibility Study discusses actions proposed to manage onsite contamination to comply with CERCLA regulations.

2800

CHAPTER 10





1 – The K-65 Silos are part of Operable Unit 4, one of the five operable units that the site is divided into for remediation.

2 – The fly ash pile is one of the solid waste facilities that make up Operable Unit 2.

3 – Operable Unit 3 consists of those areas suspected to be contaminated by Production Area activities.

4 – The waste pits, containing low-level radioactive waste, make up Operable Unit 1.

CHAPTER TEN

Remedial Investigation and Feasibility Study

The Remedial Investigation and Feasibility Study (RI/FS) is a comprehensive, long-term environmental investigation currently underway at the FMPC. Its dual purposes are to identify environmental problems at the FMPC and to define and evaluate possible solutions. The CERCLA-driven project began in 1986 and is scheduled to continue throughout the decade.

Following the organization of the RI/FS process, this chapter discusses results by operable unit:

- **Introduction to the RI/FS,**
- **Operable Unit 1** – Waste Pit Area,
- **Operable Unit 2** – Other Waste Units,
- **Operable Unit 3** – Production Area Activities,
- **Operable Unit 4** – Silos 1 - 4, and
- **Operable Unit 5** – Environmental Media.

Those readers already familiar with the RI/FS process may wish to proceed directly to Operable Unit 1. The operable unit sections in this report, however, are only summaries of the RI/FS program's progress through 1990. For more detailed information, refer to the Public Environmental Information Center's Administrative Record, the inventory of documentation for the RI/FS project.

Results in Brief: Remedial Investigation and Feasibility Study

During 1990, the FMPC continued the RI/FS as outlined by the CERCLA legislation. Remedial Investigations are underway for all five operable units while Feasibility Studies are beginning. Progress through 1990 at each operable unit is discussed in this chapter; highlights are summarized below.

OU1 – The Waste Pit removal action to address contamination in the surface runoff has been developed. The preferred action is runoff collection and treatment. Work will begin in late spring 1991.

OU2 – Long-term remedial action alternatives have been identified for the solid waste storage units, but the Remedial Action Objectives were still being reviewed by DOE and USEPA.

OU3 – Ten suspect areas have been grouped into three types of contamination for the OU3 RI. However, when a Notice of Violation was filed by USEPA in late December, progress on this RI report was suspended.

OU4 – RI data has confirmed that K-65 Silo contents pose an immediate threat to health and environment. A K-65 Silos Removal Action to cover the silo residues with bentonite clay will begin in 1991.

OU5 – After sampling a variety of environmental media, only groundwater was shown to be significantly contaminated. The South Groundwater Contamination Plume Removal Action focuses on groundwater contamination south of the site.

Introduction to the RI/FS

This introductory section is intended to place the RI/FS in a context of being a federally mandated FMPC study. This introduction discusses:

- The FMPC as a RI/FS test case,
- The origins of RI/FS at the FMPC, and
- The RI/FS process.

A RI/FS Test Case

Cleaning up our national environment has received increasing attention in recent decades. Major pieces of legislation driving the cleanup efforts have included the National Environmental Policy Act of 1969 (NEPA), the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and its companion Superfund Amendment and Reauthorization Act of 1986 (SARA).

The FMPC is one of the first among DOE facilities regulated by such legislation to undergo an integrated RI/FS process under CERCLA. In many respects, the local site is a national test case. One precedent set in the FMPC RI/FS process was USEPA's authority to regulate another federal agency's compliance with environmental laws. USEPA asserted its authority with a Notice of Violation to DOE in late December of 1990 over a report submitted on Operable Unit 3. This Notice brought about a series of meetings between USEPA and DOE officials at several levels. These meetings ended with DOE agreeing to the principle that USEPA has the right to both oversee cleanup activities and enforce compliance with regulations and standards at DOE facilities.

In the fall of 1989, USEPA and Congress placed the FMPC on the National Priorities List, further strengthening USEPA's authority over the cleanup activities. Thus, the USEPA plays an active role in determining which remedial actions are chosen for the site.

Origins of RI/FS

In July 1986, DOE and USEPA signed a Federal Facility Compliance Agreement, addressing impacts to the environment associated with operations at the FMPC. The FFCA's purpose was to ensure that the FMPC would thoroughly investigate those impacts and then implement the appropriate remedial actions.

This FFCA investigation took the form of a RI/FS, as outlined by the CERCLA legislation. The FFCA was later amended by the June 1990 Consent Agreement between DOE and USEPA to allow RI/FS work to continue divided into five operable units.

The RI/FS Process

The RI/FS investigation is conducted in a systematic manner according to strict USEPA regulations. The process consists of two distinct parts:

- **The Remedial Investigation** (RI) characterizes the nature and extent of contamination and the risks posed to people and the environment; and
- **The Feasibility Study** (FS) evaluates potential remedial options.

The scope of the RI/FS does not include taking corrective actions, rather, it is an investigative process that results in proposals for action. The FMPC will work with the USEPA to select and implement the most appropriate ***remedial actions*** for the site based on the results of RI/FS.

In contrast to the long-term corrective actions recommended by the RI/FS are ***removal actions*** which meet an immediate threat to health and to the environment. Removal actions often develop during Remedial Investigations to quickly address contamination.

Risk Assessment

Risk assessment is a part of each OU's RI report. Its scope is to:

- Identify and assess the toxicity of all radionuclides and chemicals of concern at the FMPC;
- Estimate risks to human health, the environment, and ecological receptors; and
- Support the development of preliminary and final remediation goals.

Risk assessment will have more impact as the RI/FS proceeds.

Remedial Investigation

The Remedial Investigation phase at the FMPC began in 1986. The FMPC identified 39 areas of the site to be investigated. For technical and management purposes, these 39 areas were grouped together into the five operable units specified by the Consent Agreement. The five OUs at the FMPC are:

- **Operable Unit 1** – Waste Pit Area,
- **Operable Unit 2** – Other Waste Units,
- **Operable Unit 3** – Production Area Activities,
- **Operable Unit 4** – Silos 1 - 4, and
- **Operable Unit 5** – Environmental Media.

The specific boundaries of each OU are defined in the 1990 OU summaries that follow this introduction.

Investigation results lead to an RI report for each of the five OUs. These five reports, which describe the extent of the contamination in each OU and analyze the contamination's various sources, support the Feasibility Studies.

Feasibility Study

The Feasibility Study for each OU describes and compares alternatives for remediation. These alternatives are developed to meet Remedial Action Objectives, the cleanup goals set to protect the health of people and the environment. RAOs were conceived to ensure compliance with all regulations governing FMPC contaminants of concern.

During the FS, alternatives for long-term remedial action are screened and evaluated based on the following criteria:

- Overall protection of human health and the environment,
- Compliance with applicable or relevant and appropriate requirements (ARARs),
- Long-term effectiveness and permanence,
- Reduction of toxicity, mobility, and volume through treatment,
- Short-term effectiveness,
- Implementability, and
- Cost.

Working with the USEPA, the FMPC recommends a remedial action alternative for each operable unit. Following the release of the FS reports, state and community acceptance of the recommended alternatives are evaluated. As more data are collected in the RIs, both the remedial goals and the selected alternatives may change. Thus, the RI/FS process is a long one.

RI/FS Environmental Impact Statement

The National Environmental Policy Act of 1969 (NEPA) requires that every plan for "major federal actions significantly affecting the quality of the human environment" be accompanied by an Environmental Impact Statement. Even those significant effects beneficial to the environment require an EIS.[46] DOE has determined that remedial actions proposed by the RI/FS at the FMPC will have significant positive effects on the environment. Therefore, the FMPC will prepare an EIS to assess the potential impacts of the proposed RI/FS actions. Specifically, the EIS will:

- Consider remedial action alternatives being developed for the FMPC,
- Evaluate the impacts of various site-wide alternatives (i.e., engineered waste management facility, packaging/treatment facility), and
- Evaluate the cumulative impacts of remediation across operable units.

OU Summaries in this Chapter

The brief data summaries presented here cover the RI/FS through 1990. These summaries and proposals for the OUs are neither interpretations nor descriptions of actions taken; rather, the OU sections that follow summarize the RI/FS program's progress through 1990. Each OU discussion includes:

- A description of each operable unit,
- RI data presented in a summary fashion according to media sampled and type of contaminant, and
- FS progress, including alternative actions to meet the RAOs.

Since the RI/FS is at different stages in each OU, available results will vary.

Operable Unit 1 – Waste Pit Area

The first operable unit for the RI/FS study consists of onsite facilities that were used during uranium production at the FMPC for storage of low-level radioactive waste. The operable unit covers approximately 15 hectares (37 acres) and consists of:

- Waste Pits 1 through 6,
- The Clearwell, and
- The Burn Pit.

The immediately surrounding areas affected by these storage facilities are also studied as a part of OU1 (Figure 54).

Description of Operable Unit 1

Waste Pits 1 through 6, located west of the production area, contain a variety of liquid and solid wastes which were generated by the eight separate operations plants at the FMPC. Pits 3 and 5 are referred to as *wet* because they received mostly wastes in a slurry form. Pits 1, 2, 4, and 6 are referred to as *dry* because they received mostly solid, dry wastes. The Clearwell was a settling pond and the Burn Pit contains residue from burned refuse.

Remedial Investigation

The goals of the Remedial Investigation for OU1 are to define the nature and extent of contamination originating from the waste pits, Clearwell, and Burn Pit and then to determine how much risk this contamination poses to human health and to the environment. To accomplish these RI goals, the FMPC is sampling the following media in OU1:

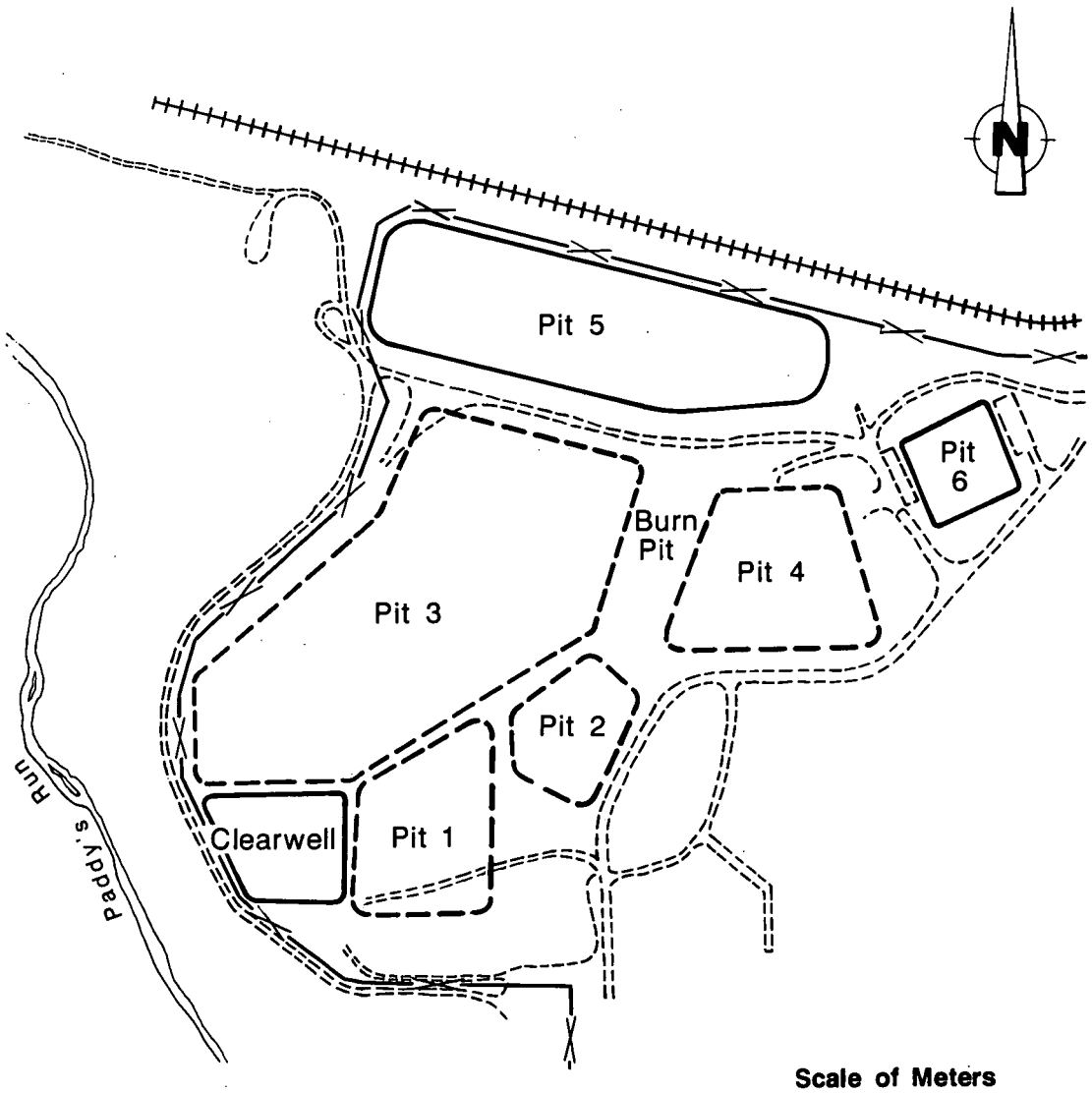
- Waste pit contents,
- Surface and subsurface soils,
- Surface water and sediment, and
- Groundwater.

Groundwater monitoring is of particular concern since contaminants from the waste pits or soil may leach into the aquifer. In a sense, protection of the aquifer is the prime concern of all RI/FS activities.

Sampling Results of the RI

The results of the Remedial Investigation for OU1 through 1990 are summarized below. Some of the data being used for the OU1 RI are from the Characterization Investigation Study (CIS) that was conducted by Weston Inc. in 1987.[47] The summarized data are presented by media.

FIGURE 54: Operable Unit 1



LEGEND

Operable Unit 1 consists of the Six Waste Storage Pits, The Clear Well and The Burn Pit.

⨯—⨯ Fence

⚌⚌⚌ Roadway

----- Covered Pit

╫╫╫╫ Railroad Spur

1302

Waste Pit Contents

During the investigation of the contents of the waste pits, both radioactive and nonradioactive contaminants were detected.

Uranium and thorium were the principal ***radioactive contaminants*** in the waste pits; technetium-99 and radium-226 were also detected. Significant results from the CIS radioactive characterization of the waste pits were:

- **Uranium** – Uranium was detected in varying amounts in all pits. Uranium-238 was highest in samples from Pit 6, ranging in concentrations from 12,500 to 18,700 pCi/g.
- **Thorium-230** – The highest concentration was 21,900 pCi/g in a sample from Pit 3; concentrations ranged from 3,080 to 20,200 pCi/g in Pit 5.
- **Technetium-99** – Technetium-99 was detected in Pits 2, 3, and 5 at maximum concentrations of 618, 110, and 2,990 pCi/g, respectively.
- **Radium-226** – Radium-226 was highest in samples from the Clearwell and Pit 5, with concentrations up to 458 and 999 pCi/g, respectively.

Other Contaminants detected in several waste pits included inorganic compounds such as aluminum and barium. Organic chemicals such as methylene chloride and butanone, semivolatile organics such as fluoranthene and naphthalene, and hazardous contaminants such as PCBs, asbestos, and DDT were detected in measurable amounts in all the pits.

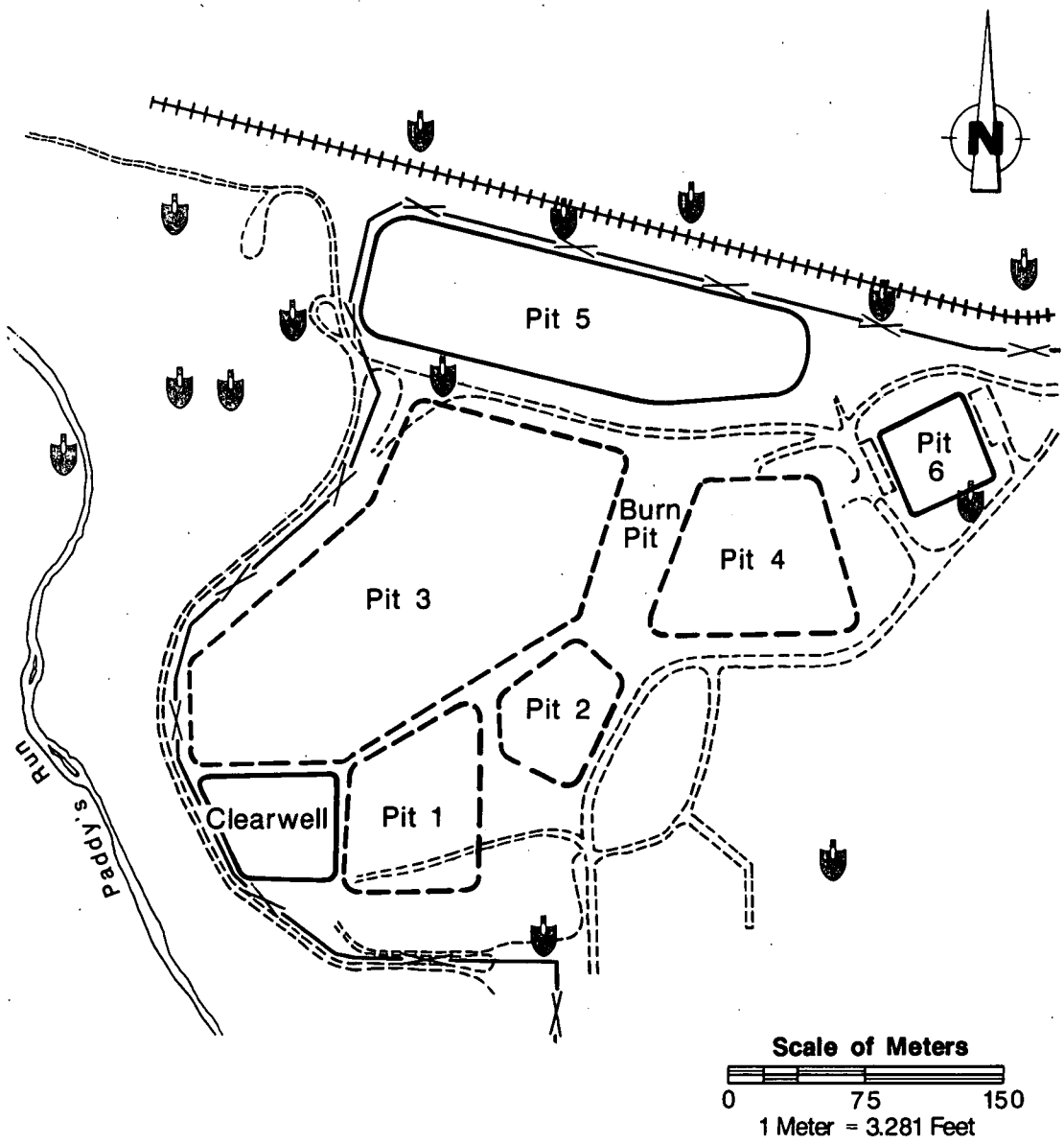
Soils

The CIS sampled the area and depth of soils to identify the types and concentrations of radioactive and chemical contaminants that may be present in OU1 (Figure 55). The soils were also sampled to provide data that will be used to determine where future sampling may be necessary. Subsurface soils were sampled to provide additional data on conditions below the FMPC facility that may influence migration pathways of contaminants.

Most of the ***surface soils*** were investigated during the CIS. Radionuclides were detected around the perimeter of Pit 6 and east of Pits 1, 2, and 4. Significant results of that detection were:

- **Uranium-238** – Uranium-238 was detected in the upper six inches of soil at some locations at concentrations greater than 100 pCi/g. The concentrations generally decrease with increasing soil depth.
- **Radium** – Radium was detected at 5 to 15 pCi/g.
- **Thorium** – Thorium was primarily detected at 1-5 pCi/g, although some samples had concentrations ranging from 5 to 15 pCi/g.

FIGURE 55: Surface Soil Sampling Locations for OU1



LEGEND

Sampling Location

Covered Pit

Fence

Roadway

Railroad Spur

1302

During the RI, 10 surface samples from 0 to 5 cm (0 to 2 inches) were collected in the waste pit area. In addition, samples were also collected from the top 46 cm (18 inches) of soil encountered while drilling wells. Concentration ranges for the most consistently detected radionuclides were:

- **Radium-226** – Concentrations ranged from 0.4 to 2.1 pCi/g.
- **Uranium-238** – Concentrations ranged from 0.6 to 32 pCi/g.
- **Thorium-230** – Concentrations ranged from 0.8 to 6.1 pCi/g.

Only uranium and thorium were detected at levels above-background. Radium concentrations were within the range of background. Overall, the concentrations of the radionuclides decreased at lower depths.

During the drilling of groundwater monitoring wells, the FMPC also investigated ***subsurface soils***. Of the 26 wells drilled in OU1 during the RI, soil was collected from 20 wells at depths of 0.46 to 37 meters (1.5 to 122 feet). A total of 22 soil samples were analyzed for a full range of radionuclides.

Radium, thorium, and uranium were consistently detected in the samples. Radionuclides detected less frequently were technetium-99 and strontium-90. The concentration ranges were:

- **Radium-226** – Concentrations ranged from 0.4 to 1210 pCi/g.
- **Thorium-230** – Concentrations ranged from 0.7 to 710 pCi/g.
- **Uranium-238** – Concentrations ranged from less than 0.6 to 320 pCi/g.

The subsurface soil data indicate that contamination at the OU1 study area has migrated from the surface to the glacial overburden. Leaching has occurred from the waste pits, and contamination has migrated to 11 meters (36 feet) below the surface.

Surface Water and Sediments

At both RI and CIS sampling locations along OU1 drainage pathways, only uranium was present in the water and sediment in significant amounts. The sampling results were:

- **Total uranium** – Concentrations ranged from 54 to 9318 µg/L in water.
- **Uranium-234** – Concentrations measured 597 and 653 pCi/L in two water samples.
- **Uranium-238** – Concentrations measured 2,840 and 2,506 pCi/L in two water samples. It ranged from 46 to 728 pCi/g in sediments near Pit 5 and from 96 to 746 pCi/g in sediment from a small drainage ditch east of Pit 4.

Groundwater

Thirty-eight groundwater monitoring wells were located in the OU1 study area. The FMPC installed 26 of these wells during the RI: twenty 1000-series wells, two 2000-series wells, and four 3000-series wells.

The FMPC's objectives for the OU1 RI groundwater investigation are to determine the nature and extent of groundwater contamination and to determine the rate and flow within each separate water-bearing zone. The FMPC sampled the wells quarterly and analyzed them for radionuclides and water quality indicators. Selected wells were analyzed for organic chemicals.

Significant ***radioactive contaminant*** results for the groundwater investigation were:

- **Total uranium** – Concentrations in the 1000-series wells varied from less than 1.0 to 15,333 µg/L. Wells located near waste pits repeatedly had concentrations greater than 500 µg/L. Total uranium concentrations in the aquifer were much lower than in the glacial overburden. Concentrations ranged from <1.0 to 78 µg/L in the 2000-series wells and from <1.0 to 218 µg/L in the 3000-series wells.
- **Other radionuclides** – Thorium-230, thorium-232, radium-226, and technetium-99 were repeatedly detected in perched groundwater in the vicinity of the pits.

The FMPC also detected ***chemicals and elevated pH*** levels during the OU1 RI. Significant results of those detections are:

- **Chemicals** – Statistically elevated concentrations of chemicals such as barium, calcium, and magnesium were detected, indicating that the pits are contributing various radionuclides and chemicals to the glacial overburden.
- **Elevated pH** – Elevated pH values measured in well 1031 appear to be directly related to leakage from the Clearwell.

Waste Pit Area Runoff Control Removal Action

Available data have shown that releases to the environment from OU1 have contaminated the surface soils, the glacial overburden, and the groundwater beneath the waste pits. Acting on the potential for immediate threat to health and to the environment that this contamination poses, a removal action has been initiated for OU1.

The 1990 Consent Agreement provided for an OU1 removal action to manage radioactively contaminated stormwater runoff from the waste pit area (Figure 56). The objectives of this removal action are to:

- Control the release of uranium in stormwater runoff to protect

human health and the environment,

- Protect organisms in Paddy's Run, and
- Protect the Great Miami Aquifer from contaminants in the surface water.

The following five alternatives have been developed through 1990 for the waste pit removal action:

Alternative 1 – No action.

Alternative 2 – Placing a cap over the area to prevent rain water from reaching contaminated soil.

Alternative 3 – Adding a collection system to intercept any subsurface fluid to Alternative 2.

Alternative 4 – Placing a runoff collection system in the area to separate contaminated from noncontaminated stormwater runoff. The contaminated water will be treated.

Alternative 5 – Removing all wastes and contaminated soils.

More details about these alternatives and the screening process used to evaluate the alternatives are available in the *Engineering Evaluation/Cost Analysis (EE/CA) — Waste Pit Area Stormwater Runoff Control*, located in the PEIC.

No-Action Alternative

The process of developing alternatives must always include taking no action as a baseline against which to measure all other alternatives. All the operable unit studies use this analytical tool.

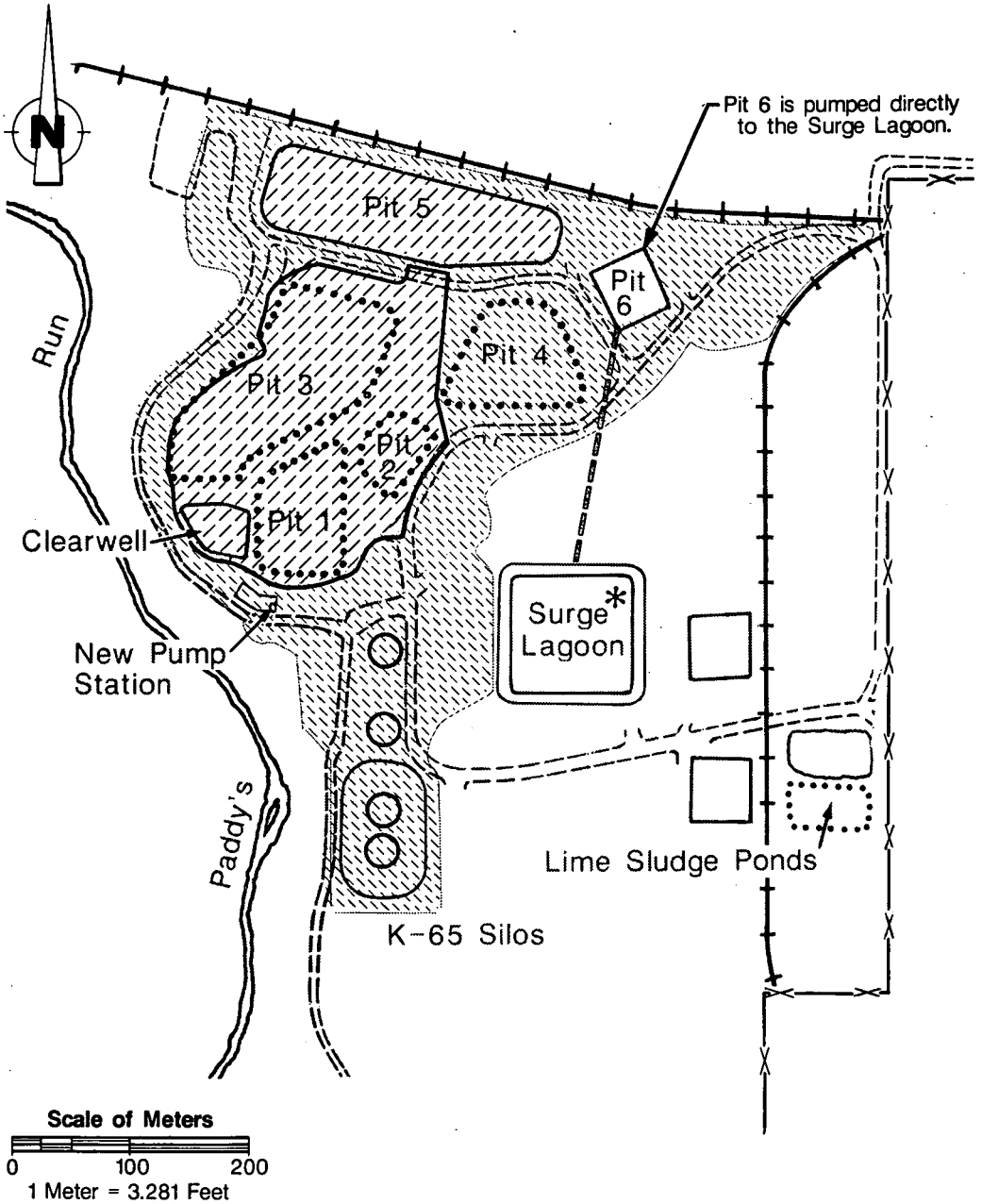
Based on the comparative analysis presented in the EE/CA, Alternative 4, runoff collection and treatment, is the preferred removal action for the stormwater runoff from the waste pit area. This alternative is consistent with all final remedies being considered for both the waste pits and the regional environmental media. It effectively protects human health and the environment, yet can be completed in a shorter time and at a lower cost than the other alternatives. This removal action will begin in late spring 1991.

Feasibility Study

Through the Feasibility Study, the FMPC identifies and recommends the methods that will be most effective in meeting the Remedial Action Objectives for OU1. The RAOs for OU1 have been developed for:

- Direct radiation
- Air
- Soils
- Sediments
- Surface water
- Perched groundwater
- Operable unit wastes

FIGURE 56: Proposed Stormwater Runoff Control for Waste Pit Area



LEGEND

- This Area Will Drain to the Exisiting Clearwell
- This Area Will Drain to New Pump Station
- Production Area Perimeter
- * All Shaded Areas Will be Pumped to Surge Lagoon

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The following are the alternatives for OU1 remediation developed through 1990 to meet these RAOs:

- *In situ* stabilization of wastes, slurry wall to prevent subsurface migration of contaminants, and a cap;
- Removal and treatment of wastes and underlying soils by cement stabilization with either onsite or offsite disposal;
- Removal and treatment of wastes and underlying soils by vitrification with either onsite or offsite disposal; and
- Removal and treatment of wastes and capping of the remaining soils.

As more data are collected, both the remediation goals and the alternatives selected to meet those goals may change.

Operable Unit 2 – Other Waste Units

The second operable unit consists of those facilities used for the storage or disposal of solid wastes from now discontinued FMPC operations (Figure 57). These waste units are:

- The Solid Waste Landfill,
- North and South Lime Sludge Ponds,
- Inactive Fly Ash Disposal Area,
- Active Fly Ash Pile,
- The Southfield Disposal Area, and
- Berms, liners, and soils within the OU2 boundary.

The wastes that have been stored or disposed of in these facilities consist of fly ash, spent lime, sanitary waste, and construction rubble.

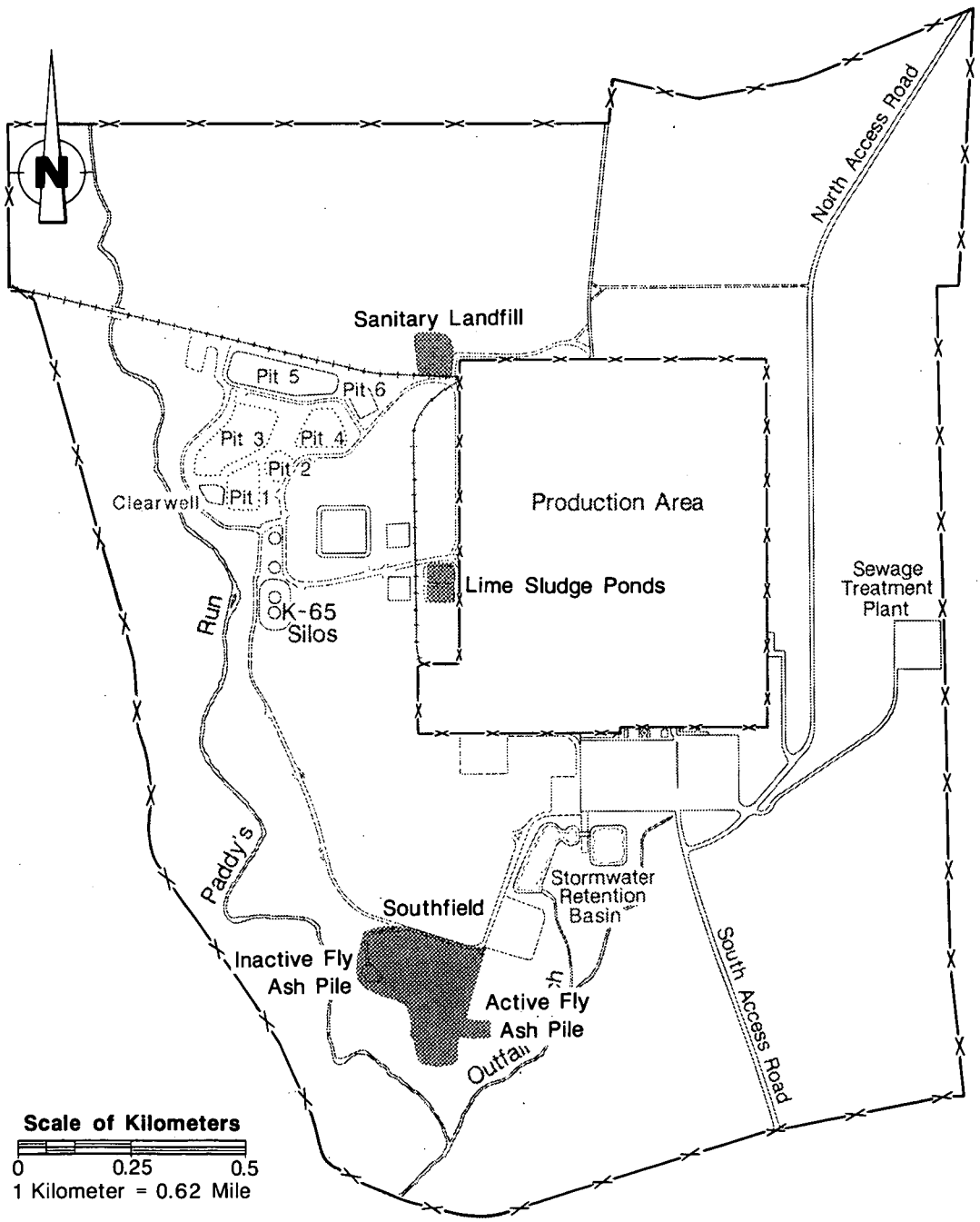
Description of Operable Unit 2

The primary characteristic of the waste units in OU2 is that they involve large volumes of waste with small percentages of hazardous chemicals or radionuclides.

The Solid Waste Landfill is located on a 0.61 hectare (1.5 acre) tract in the northeast corner of the waste storage area. The landfill operated from 1954 to 1986 and received about 12,000 to 14,000 m^3 (16,000 to 18,000 cubic yards) of cafeteria wastes, rubbish, and other wastes from nonprocess areas. In addition, asbestos and radionuclide-contaminated construction rubble and soil may have been disposed of in the landfill.

The unlined North and South Lime Sludge Ponds, which receive spent lime sludges from the FMPC drinking water treatment plant, are in the

FIGURE 57: Operable Unit 2



LEGEND

- Operable Unit 2
- Covered Pit
- Fence
- Roadway
- Railroad Spur

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southeastern corner of the waste storage area. The North Pond, with a total volume of 3,800 m^3 (5,000 cubic yards), is approximately 90% full and partially covered with water. The recently reactivated South Pond, with a total volume of 3,800 m^3 (5,000 cubic yards) is dry and is used sparingly.

The Inactive Fly Ash Disposal Area is located about 610 meters (2,000 feet) southwest of the Production Area. An estimated 50,500 m^3 (66,000 cubic yards) of fly and bottom ash and building rubble (concrete, gravel, asphalt, and steel rebar) were disposed of in this area until the mid-1960s.

The Active Fly Ash Pile is an uncovered storage area located just east of the Southfield Disposal Area, with an estimated volume of 45,000 m^3 (59,000 cubic yards). Fly and bottom ash from the coal-fired boiler plant are disposed of in this area. Elevated levels of uranium were found in both of these areas.

The Southfield Disposal Area is reported to have been used as a burial site for construction rubble that may have contained low levels of radioactivity. Other wastes may have been deposited here as well although supporting records are not available. For purposes of the RI/FS, the Southfield Disposal Area is assumed to cover approximately 4.5 hectares (11 acres) with a volume of 95,500 m^3 (125,000 cubic yards) of waste.

Remedial Investigation

The goal of the Remedial Investigation for OU2 is to establish whether or not the wastes stored or disposed of in the OU2 facilities are sources of contamination to the environment. The RI sampling for OU2 has already included the following media:

- Surface water and sediments,
- Surface soils,
- Subsurface soils, and
- Groundwater.

Additional sampling proposed for 1991 will include five borings in the landfill, four each in the Inactive and Active Fly Ash Piles and the Southfield Disposal Area, and two borings in the Lime Sludge Ponds. The additional sampling is scheduled to begin by late spring.

Sampling Results of the RI

The results of the Remedial Investigation for OU2 through 1990 are summarized below. The data are presented by media.

Surface Water and Sediment

The main objective of the surface water and sediment sampling program in OU2 is to characterize how radioactive and chemical contaminants are distributed along the drainage pathways toward Paddy's Run. Surface water samples were collected at two points in the drainage pathways north of the Solid Waste Landfill; surface water and sediment samples were collected at eight locations in the Fly Ash/Southfield Disposal Area areas. Water samples were analyzed for radionuclides, organic compounds, and several water quality parameters. Sediment samples were analyzed for radionuclides, hazardous substances, and grain size.

Significant results from the RI radioactive characterization of the surface water and sediments in OU2 are:

- **Uranium-234** – In the Solid Waste Landfill, uranium-234 was detected at above-background levels.
- **Uranium-238** – Uranium-238 was detected at above-background levels in the Solid Waste Landfill.
- **Total uranium** – In the Fly Ash/Southfield Disposal Area areas, total uranium was detected in all surface water samples, ranging from 7.0 to 1,692 µg/L, and in all sediment samples, ranging from 4.5 to 52 µg/L. The locations with the highest uranium contamination are on the western slope of the Active Fly Ash Pile.
- **Radium** – Radium was detected in one surface water sample and all sediment samples at or slightly above-background levels (less than 0.5 µg/L for water and 0.7 µg/L for sediment).

Based on the uranium-238 detected in the drainage pathway north of the landfill, the landfill may be a minor source of contamination through its surface water runoff or seepage. The concentrations of total uranium and chemicals detected in the surface water and sediment of the Fly Ash/Southfield Disposal Area areas can be attributed to the naturally occurring composition of the fly ash.

Surface Soils

The objective of the surface soil testing in OU2 is to determine the extent of contamination in the soils and to characterize the radionuclides that have the potential to contribute to offsite contamination. Surface samples were collected near the drainage pathway that lies to the north of the Solid Waste Landfill and from the Fly Ash/Southfield Disposal Area areas. The soil samples were analyzed for radionuclides representative of materials found at the FMPC.

- **Uranium-238** – Concentrations at three upgradient locations in the Solid Waste Landfill were 44 pCi/g, 25 pCi/g, and 24 pCi/g. Concentrations in the downgradient samples were 8 pCi/g at a location west of the landfill and ranged from 133 to 228 pCi/g

at a location adjacent to the northwest corner of the Solid Waste Landfill. Uranium-238 was also present in three samples at the Fly Ash/Southfield Disposal Area areas in concentrations ranging from about 3 to 16 pCi/g.

- **Thorium-230** – Thorium-230 was detected in the Fly Ash/ Southfield Disposal Area areas at or slightly above-background (1.4 pCi/g) in three samples, ranging from 1.5 to 4.3 pCi/g.

In the Solid Waste Landfill, the radionuclides detected in the soils can most likely be attributed to contaminated runoff and airborne deposits from the FMPC Production Area. The elevated uranium-238 in the Fly Ash/Southfield Disposal Area areas can most likely be attributed to naturally occurring uranium in the fly ash and to the past practices of spraying uranium-contaminated oil to control dust. Contaminated surface water runoff also may have made minor contributions to the elevated uranium levels.

Subsurface Soils

The main objective of the subsurface soils investigation is to understand the conditions that may influence contaminant migration and to define the nature and extent of contamination in the subsurface soils. Samples were taken while drilling groundwater monitoring wells. They were tested for radionuclides used, stored, or produced at the FMPC.

- **Thorium** – Thorium was present in the Solid Waste Landfill at levels slightly above-background.
- **Uranium-238** – Uranium-238 was detected in the Solid Waste Landfill at 18 pCi/g. It was also detected in one sample in the Lime Sludge Ponds at a concentration of 5.9 pCi/g.
- **Uranium-234** – Uranium-234 was detected in one sample at a concentration of 2.8 pCi/g.
- **Total uranium** – Total uranium was detected in four samples in the Fly Ash/Southfield Disposal Area areas with concentrations ranging from 3 to 16 pCi/g.

The radionuclides detected above-background levels in one or more of the subsurface borings in the Fly Ash/Southfield Disposal Area areas were radium, strontium, technetium, thorium, and uranium.

A likely source of Solid Waste Landfill contamination is the surface soil adjacent to the northwest corner of the landfill. The presence of uranium in a borehole at the east berm of the south Lime Sludge pond can probably be attributed to airborne deposits from the FMPC Production Area. The Lime Sludge Ponds are not a source of contamination to the adjacent subsurface soils.

Groundwater

The principal objective of the OU2 groundwater sampling is to determine if OU2 areas are a source of contamination to perched water and the Great Miami Aquifer. A total of 27 monitoring wells have been installed in OU2 during the RI.

- **Uranium-234** – Concentrations detected in perched groundwater sampling in the Solid Waste Landfill ranged from 1.2 to 4.6 pCi/L. It was detected in the perched groundwater beneath the Lime Sludge Ponds in concentrations ranging from 1.4 to 9.5 pCi/L. Uranium-234 was detected in the Fly Ash/Southfield Disposal Area areas with a highest reading of 7.4 pCi/L.
- **Uranium-238** – Concentrations in perched groundwater sampling in the Solid Waste Landfill ranged from 1.0 to 3.9 pCi/L. Uranium-238 concentrations detected in the perched groundwater beneath the Lime Sludge Ponds ranged from 1.7 to 9.7 pCi/L.
- **Thorium-230** – The highest concentration of thorium-230 detected in the perched groundwater beneath the Lime Sludge Ponds was 1.6 pCi/L (background is 0.1 pCi/L) measured in the east berm of the South Pond. The highest reading for thorium in the Fly Ash/ Southfield Disposal Area areas was 1.1 pCi/L.
- **Cadmium** – Concentrations in perched groundwater sampling in the Solid Waste Landfill ranged from 0.007 to 0.0128 µg/g (background is 0.0022 µg/g) with the highest levels observed at the southern edge of the landfill. Cadmium was also detected in the Fly Ash/Southfield Disposal Area areas at a highest reading of 0.003 µg/g.

Feasibility Study

Though the Feasibility Study for OU2 has started, the RAOs for OU2 are still under review by DOE and USEPA. They will be established before the continuation of the FS. As of 1990, FS initial screening of alternatives for long-term remedial action has identified the following alternatives:

Solid Waste Landfill

- Containment,
- Containment with perched groundwater treatment,
- Removal and treatment of waste/perched groundwater and onsite disposal, and
- Removal and treatment of waste/perched groundwater and offsite disposal.

Lime Sludge Ponds

- Containment with *in situ* stabilization,
- Containment with *in situ* stabilization and perched groundwater treatment:
  - Removal and treatment of waste/perched groundwater and onsite disposal;
  - Removal and treatment of waste/perched groundwater and offsite disposal.

Fly Ash/Southfield Disposal Area

- Containment,
- Containment with perched groundwater treatment,
- Removal and treatment of waste/perched groundwater and onsite disposal, and
- Removal and treatment of waste/perched groundwater and offsite disposal.

Operable Unit 3 – Production Area Activities

The third operable unit addresses surface and subsurface radioactive and hazardous chemical contamination of soils and perched groundwater that may be attributed to Production Area activities (Figure 58). The 10 areas suspected to be contaminated by production operations addressed under OU3 are:

- The area within the east buffer zone,
- The Clearwell to Manhole-175 pipeline,
- The fire training area,
- The flagpole area near the old administration building site,
- The Sewage Treatment Plant/incinerator area,
- The K-65 slurry line,
- The main effluent line,
- The rubble mound west of the K-65 Silos,
- The rubble mound south of the K-65 slurry line, and
- The rubble mound in the northeast corner of the pit area.

Description of Operable Unit 3

Due to the complexity of the various contaminated zones and surrounding structures, facilities, and utility lines, it is difficult to address OU3 problems on an area-by-area basis. The difficulty has been solved by grouping contaminated areas according to type of problem. The problem categories for OU3 include:

- Soil contamination,

- Perched groundwater contamination, and
- Contamination related to scrap metal and discarded equipment and materials.

Remedial Investigation

The dominant contaminant in the soils and perched groundwater in OU3 is uranium. However, all identified radiological, organic, and inorganic contaminants will be addressed through the RI/FS process.

Sampling Results of the RI

Because of the number of suspected areas covered under OU3, results here are summarized according to types of contamination.

Soil Contamination

RI data show that the majority of soils containing uranium exceeding the preliminary RAO of 50 µg/g are located in the top 0.46 meters (1.5 feet) of surface material. Data also show that about 50% of Production Area soils exceed these levels.

- **Total Uranium** – Levels between 200 and 500 µg/g are found in isolated areas throughout the Production Area. Concentrations of 90,000 and 7,000 µg/g were detected around Plant 6.
- **Other radionuclides** – Additional contaminants found in OU3 soils are magnesium, thorium, manganese, radium-226, and technetium-99.

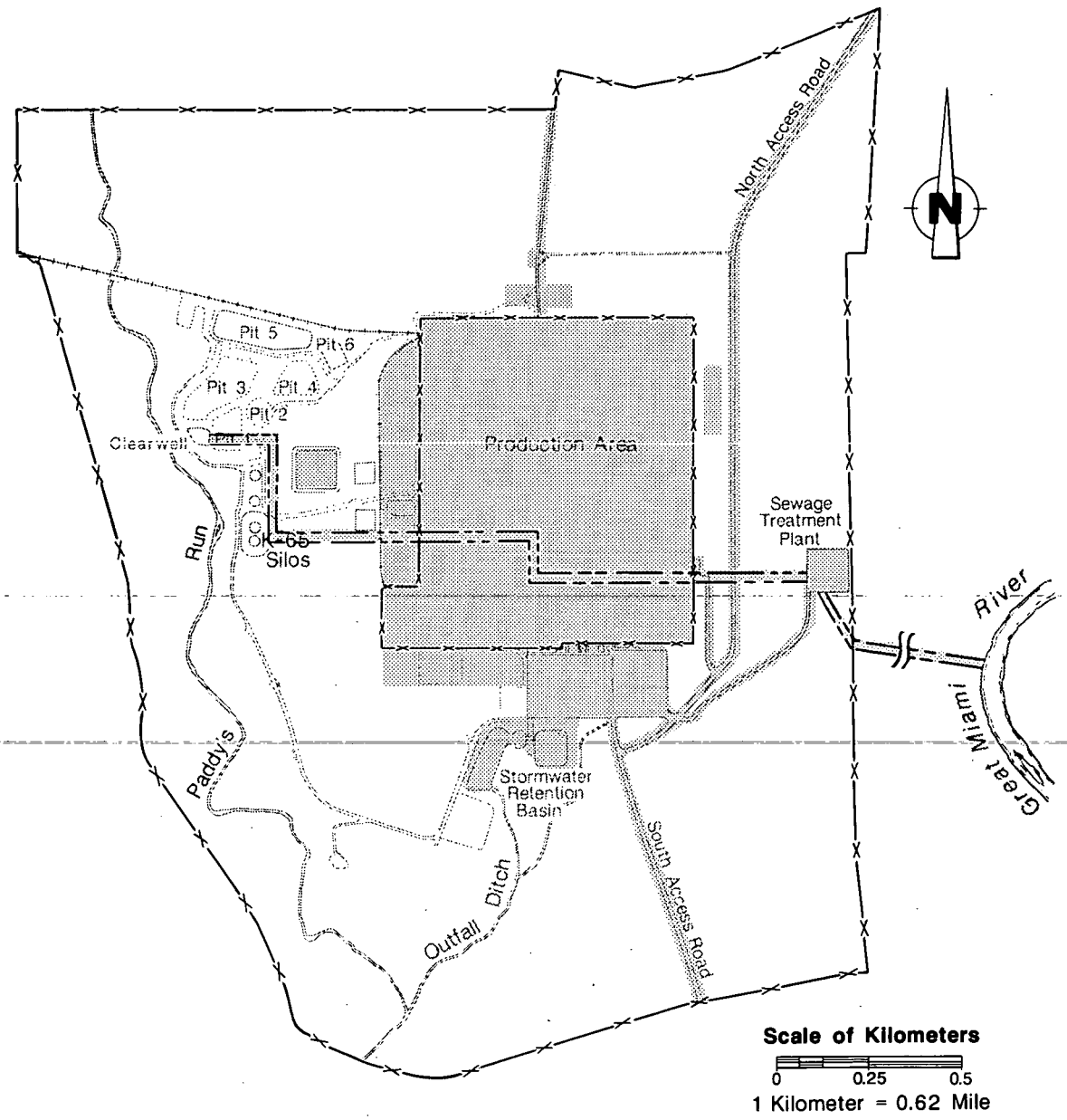
Perched Groundwater Contamination

Approximately 80% of the groundwater samples taken from the Production Area contained measurable levels of uranium.

- **Total uranium** – Plumes have been recorded with levels between 1,000 and 50,000 µg/L. Two exceptions were readings of 146,000 µg/L from a boring east of Plant 6 and 696,000 µg/L from a boring at the south end of Plant 9.
- **Other radionuclides** – Thorium, radium-226, and technetium-99 were also detected in perched groundwater within OU3.

Nonradioactive pollutants found in OU3 included dichloroethene and trichloroethene which were detected near Plant 2/3 and Plant 9. Chlorinated organics and benzene related compounds were detected at concentrations less than 40 µg/L. Total xylenes were detected at 300 to 400 µg/L and vinyl acetate and 4-methyl-2-pentanane was detected at less than 10 µg/L east of the garage. Magnesium, manganese, molybdenum, aluminum, and vanadium were detected at above-background levels northeast of the decontamination pad.

FIGURE 58: Operable Unit 3



LEGEND

- Operable Unit 3
- Clearwell to Manhole 175 and Main Effluent Line
- Plant Perimeter
- Production Area Perimeter

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Contamination Related to Scrap Metal and Discarded Equipment and Materials

Uranium contamination levels were relatively low on the various scrap metals found in the Production Area. Preliminary radiological surveys of miscellaneous scrap material and equipment in the former drum baling area indicated only low levels of uranium. Visual inspections of the area noted construction materials and transformers that may be sources of asbestos and PCBs. Additional testing is required for these materials.

At the end of the year, USEPA challenged the scope of the OU3 investigations with a Notice of Violation. Work on the RI report was halted pending resolution of the issues.

Removal Actions in OU3

RI findings have noted several areas of contamination in OU3 which require immediate attention. These have led to numerous removal actions — some completed, some in process, and some being planned. Most are relatively small-scale actions and are being treated as "time-critical" by DOE, in accordance with the Consent Agreement. The pumping of contaminated perched groundwater from beneath Plants 2/3, 6, and 9, and removal of contaminated soil from an area near the old incinerator located at the sewage treatment plant are two of the major removal actions for OU3.

Feasibility Study

Due to OU3's unresolved definitions, the FS is in its earliest stages. Alternatives tentatively developed for initial screening will need to be re-evaluated in light of decisions resulting from the dispute resolution process between DOE and USEPA.

Operable Unit 4 – Silos 1 – 4

The fourth operable unit consists of:

- The two K-65 Silos (Silos 1 and 2),
- The metal oxide silo (Silo 3), and
- The empty Silo 4.

OU4 is partially fenced and bounded by an exclusion zone surrounding Silos 1, 2, and extending to the north of Silo 4 (Figure 59).

Description of Operable Unit 4

Silos 1 and 2 are concrete storage structures containing radium-bearing residues from past DOE operations. The two silos contain approximately 8,800 metric tons (9,700 tons) of residues remaining from the processing of pitchblende, a uranium-rich ore.

Silo 3 received only dry materials. Slurries from refinery operations were dried in an evaporator and reduced to a dry waste which was blown into Silo 3. These wastes were primarily metal oxides.

Silo 4 was never used. Although standing water in this silo contains low concentrations of uranium and inorganic chemicals, Silo 4 is not considered to be a past, current, or future source of contaminant release to the environment. Its need for remediation under the RI/FS is undetermined.

Remedial Investigation

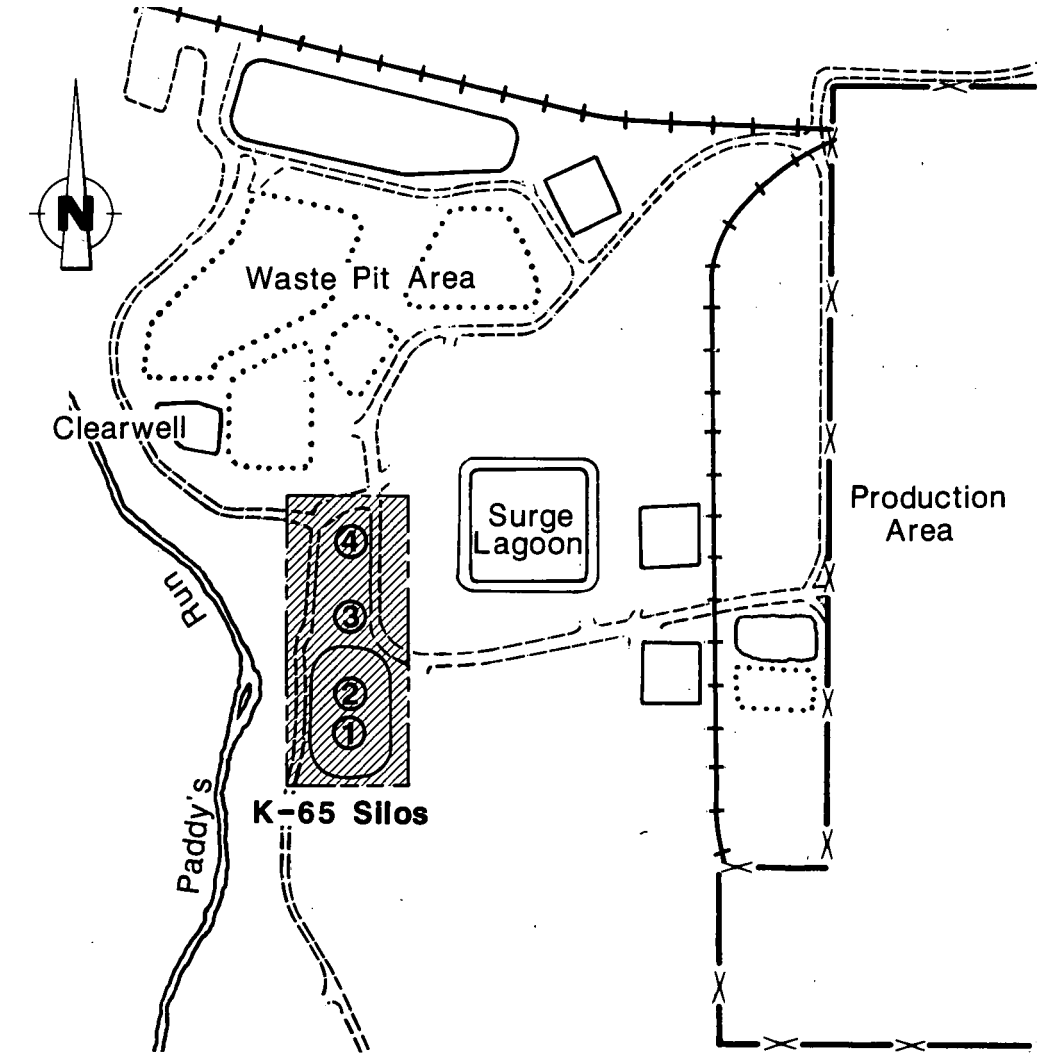
The goal of the Remedial Investigation for OU4 is to define the nature and extent of contamination originating from the silos and to determine the risk to human health and the environment associated with this contamination. The FMPC began the OU4 RI by focusing on the contents of the K-65 Silos and systematically expanding outward. The following media are being sampled in this process:

- Silo contents,
- Silo structure,
- Soil in the berms and beneath the silos, and
- Regional environment such as groundwater, surface water, sediment.

Sampling Results of the RI

The results of the Remedial Investigation for OU4 through 1990 are summarized below. The data are presented by media.

FIGURE 59: Operable Unit 4



LEGEND

Operable Unit 4

Single Well

Fence

Roadway

1302

Silo Contents

The silo contents required complete characterization as part of the RI. The objectives of the sampling were to determine:

- The depth and volume of material in the silos,
- The radioactive and chemical composition of the contents, and
- The physical properties of the silo contents in order to predict behavior of wastes during treatment and disposal.

All three silos were sampled during the summer of 1989 using a vibracore system consisting of an air-operated, vertically vibrating head assembly. The sampling of Silo 3 was considered adequate; however, the sampling of Silos 1 and 2 did not return the continuous core samples which were necessary to fully characterize the waste layers that exist in these silos. Repeat sampling of Silos 1 and 2 began in late 1990, using a modified vibracore system.

Significant results from the 1989 sampling for ***radioactive contaminants*** were:

- **Radium-226** – Concentrations in samples from Silos 1 and 2 range from 657 to 193,000 pCi/g. Radium-226 concentrations in Silo 3 are lower, ranging from 467 to 6,435 pCi/g.
- **Thorium-230** – Concentrations in Silos 1 and 2 range from 8400 to 41,000 pCi/g. The concentrations in Silo 3 are almost twice those of Silos 1 and 2, ranging from 21,000 to 72,000 pCi/g.
- **Total uranium** – Total uranium is present in Silos 1 and 2 in concentrations ranging from 137 to 3,700 µg/g and in Silo 3 in concentrations ranging from 740 to 4,600 µg/g.
- **Lead-210** – Lead-210 was detected in Silos 1 and 2 at concentrations ranging from 49,000 to 399,000 pCi/g.

The results of the analyses for ***inorganic chemicals*** indicate that there are differences in the chemical composition of the contents of Silos 1 and 2 and Silo 3. The principal inorganic compounds detected in Silos 1 and 2 are barium, calcium, iron, lead, and magnesium. The principal inorganic elements detected in Silo 3 are aluminum, calcium, iron, magnesium, potassium, and sodium.

PCBs were detected in samples from Silos 1 and 2 at concentrations up to 12,000 ppb. No PCBs were detected in Silo 3. Toluene was the only organic constituent observed in Silo 3 samples and was present in concentrations above the background concentrations contained in the laboratory method blanks.

Soils

The objectives of the surface soils sampling were to determine the extent of radioactive contamination in OU4 and to locate where future surface soil sampling may be necessary. The main objective of the subsurface sampling was to understand the characteristics of subsurface soils that might influence the movement of contaminants to the groundwater.

Ten ***surface soil*** samples were collected and analyzed for radionuclides representative of materials at the FMPC. Results of the analyses indicated that uranium was the most prevalent radionuclide in surface soils.

- **Uranium-238** – Concentrations ranged from 1.7 to 21.1 pCi/g, with two locations having concentrations above 10 pCi/g.
- **Radium** – Concentrations ranged from less than 0.3 to 4.2 pCi/g.
- **Thorium-230** – Concentrations ranged from 1.0 to 8.4 pCi/g.

Subsurface soils from eight locations were investigated during the drilling of the groundwater monitoring wells. Results of subsurface soil sampling indicate that contaminants present in the subsurface soils tend to "stick" to the soil particles. This slows their movement through the soil to the groundwater.

All subsurface soil samples were analyzed for the radionuclides used, stored, or produced at the FMPC. The radionuclides present in measurable concentrations were:

- **Uranium-238** – Concentrations were less than 0.6 to 15 pCi/g.
- **Thorium-230** – Concentrations ranged from 0.7 to 4.9 pCi/g.
- **Technetium-99** – Concentrations ranged from 0.9 to 3.9 pCi/g.
- **Radium-226** – Concentrations ranged from less than 0.3 to 1.5 pCi/g.

One sample location just north of Silo 4 had the highest measured concentrations of all radionuclides listed above. This sample was collected at a depth less than 46 cm (18 inches) and is actually more representative of surface than subsurface soils. Typically, the subsurface soils contained radionuclide concentrations of less than 2.0 pCi/g. These data indicate that contamination is limited to the surface. There does not appear to be any substantial migration to the subsurface.

Additional sampling is needed to understand the extent of contamination in soils directly below and surrounding the K-65 Silos. This additional sampling will be conducted during 1991.

Surface Water and Sediment

Surface water and sediment samples were collected from drainage pathways and from Paddy's Run within the OU4 study area to determine

if this area of the FMPC is a potential source of contaminants to Paddy's Run and the Great Miami River. The samples were analyzed for radionuclides and organic and inorganic chemicals.

A total of six surface water samples were collected from within the OU4 study area. Significant results from those samples were:

- **Total uranium** – Concentrations in samples ranged from about 200 µg/L to about 2,200 µg/L. The sample with the lowest concentration was collected east of Silo 3 and southwest of the Biodenitrification Surge Lagoon. The sample with the highest concentration was collected from a drainage pathway south of the K-65 Silos. One sample collected from Paddy's Run downstream of both the K-65 Silos and the drainageway contained total uranium concentrations of 5 to 12 µg/l.

Significant results from the sediment samples collected from two OU4 locations were:

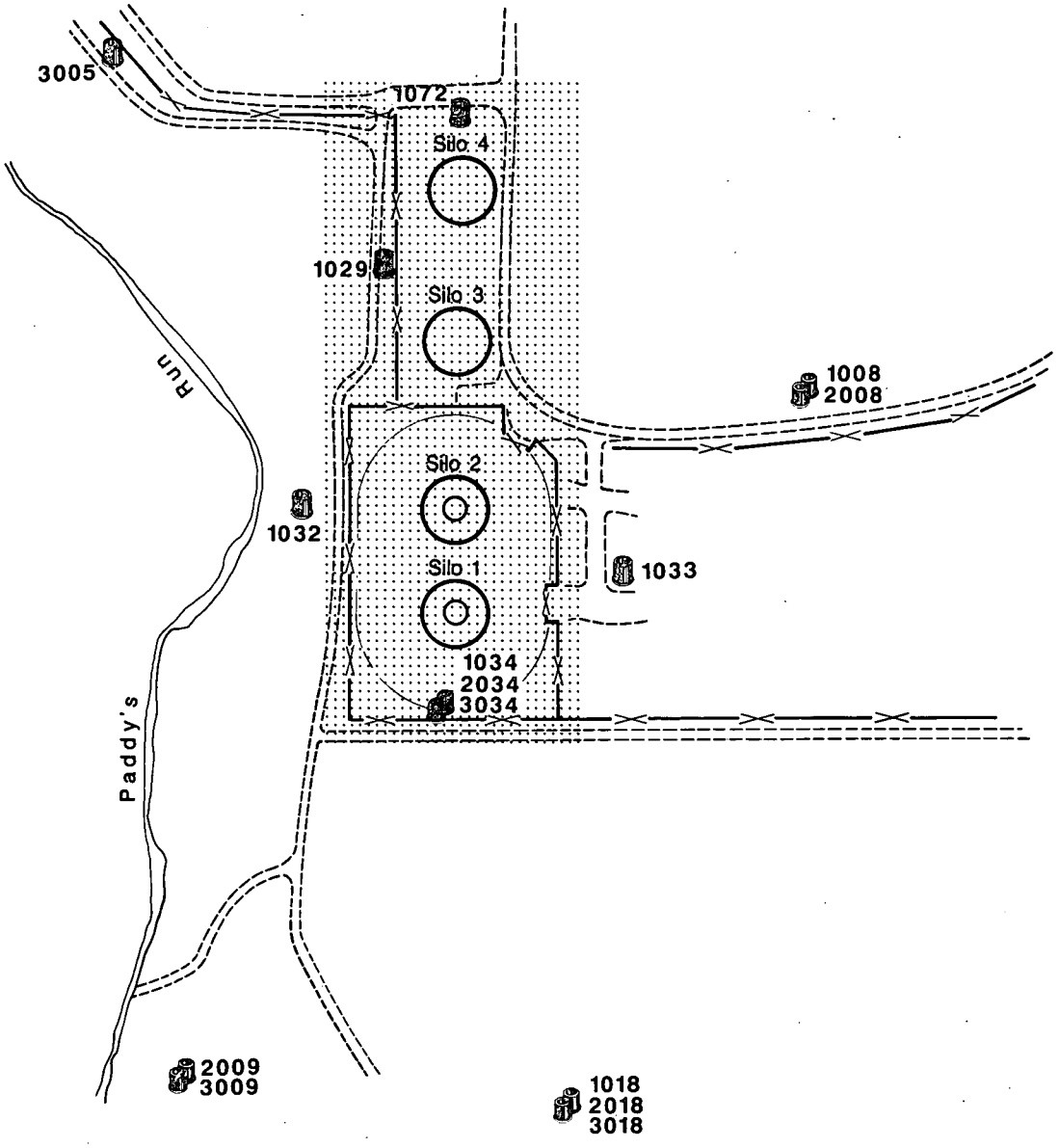
- **Total uranium** – Sediment in a drainage pathway south of the K-65 Silos contained about 30 µg/g of total uranium. Sediment collected from Paddy's Run downstream from this drainage pathway contained a maximum concentration of total uranium of 3.0 µg/g. Based on similar studies of water and sediment conducted in OU1, runoff from the pits is suspected to be the source of surface water and sediment contamination in OU4. There is no evidence that the K-65 Silos are contributing to the contamination.

Groundwater

The objective of the groundwater investigation was to determine the nature and extent of groundwater contamination and to determine the rate and direction of groundwater flow. In addition to four previous wells, 12 monitoring wells were installed within the OU4 study area during the RI. Fourteen wells in the OU4 study area were sampled quarterly: six 1000-series, four 2000-series, and four 3000-series (Figure 60).

In some 1000-series wells, total uranium ranged from 3 to 256 µg/L. Slightly elevated total uranium concentrations were detected in three of the four 2000-series wells sampled, in concentrations ranging from 15 to 22 µg/L. Total uranium concentration in the fourth well was 2 µg/L, a level close to background for the site (less than 1 to 2 µg/L). Total uranium concentrations in the four 3000-series wells was lower than in the 1000-series and 2000-series wells. Total uranium was below 4 µg/L in all wells except well 3005, which had 10 µg/L during one sampling round.

FIGURE 60: Groundwater Sampling Locations near the K-65 Silos



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Silos 1 & 2 Removal Action

Available RI data suggests that contamination originating from the K-65 Silos may pose a risk to human health and the environment. Acting on this potential for immediate threat, a removal action has been instigated.

The 1990 Consent Agreement requires a removal action at the K-65 Silos to provide short-term protection to the public and environment while the RI/FS is being conducted. The objectives of this removal action are to:

- Reduce routine emissions of radon from the K-65 Silos;
- Control radon gas in the head space which would pose a threat in the event of structural failure; and
- Stabilize the silo structure in the event of a tornado.

The following seven alternatives have been developed for the K-65 Silos Removal Action:

Alternative 1 – No action.

Alternative 2 – Construction of tornado-resistant enclosure.

Alternative 3 – Relocation of residues.

Alternative 4 – Construction of light-structure enclosure with continuous radon removal.

Alternative 5 – Covering the K-65 residues.

Alternative 6 – Reduction of radon inventory.

Alternative 7 – Administrative controls.

On the basis of the comparative analysis presented in the EE/CA, Alternative 5 was the recommended alternative. The K-65 residues will be covered with about one foot of bentonite, a moist, clay-like material. Bentonite has been used at other sites as a radon barrier, and it offers the most immediate protection from the effects of a dome failure. Work on the removal action will take place in 1991.

Feasibility Study

Through the OU4 Feasibility Study, the FMPC identifies and recommends the methods that will be most effective in meeting the Remedial Action Objectives for OU4. Separate remedial alternatives to meet the RAOs have been developed for Silos 1 and 2, Silo 3, and Silo 4. If the additional sampling identifies any contaminated soil or water below the silos, they will be incorporated into the remedial action program. Through 1990, seven alternatives have been proposed for Silos 1 and 2, six for Silo 3, and four for Silo 4.

Alternatives for long-term remedial action for OU4 have been evaluated using the following criteria:

- Short-term and long-term protection of public health,
- Short-term and long-term protection of the environment,
- Reduction in mobility, toxicity, volume,
- Constructability,
- Reliability,
- Maintenance,
- Agency approvals, and
- Special engineering and equipment.

Below are the preferred alternatives for long-term remedial action developed for OU4.

Silos 1 and 2

- In-place stabilization of wastes, cap over the silos.
- Removal and treatment of wastes with either onsite or offsite disposal.
- Removal of wastes and separation of contaminants with either onsite or offsite disposal.

Silo 3

- In-place stabilization of wastes, cap over the silo.
- Removal of wastes with either onsite or offsite disposal.

Silo 4

- Removal of contaminated water, silo demolition, and either onsite or offsite disposal.

Operable Unit 5 – Environmental Media

The fifth operable unit consists of environmental media that can serve as pathways for transporting contaminants. These media may be currently or potentially affected by FMPC contaminants. The environmental media that make up OU5 are:

- Surface water and sediments,
- Soils,
- Flora and fauna,
- Ambient air, and
- Groundwater.

Description of Operable Unit 5

Surface water channels included in OU5 are the Great Miami River, Paddy's Run, and the Storm Sewer Outfall Ditch. The river receives the site effluent discharge. Paddy's Run receives natural surface runoff and loses flow to the aquifer through its highly permeable channel bottom. The Storm Sewer Outfall Ditch may receive excess stormwater runoff from the Stormwater Retention Basin, in addition to runoff from the eastern area of the site.

All soils not accounted for in the other operable units and in areas outside the FMPC boundary are investigated in this OU. Flora and fauna sampled include terrestrial vegetation and animals, aquatic communities in the Great Miami River and Paddy's Run, locally grown produce and crops, cattle grazing on potentially affected land areas, wetlands, and threatened and endangered species. Ambient air samples may have received uranium from stacks and fugitive emissions and also radon from the K-65 Silos.

The groundwater of the Great Miami Aquifer is sampled because of its importance to the region.

Remedial Investigation

The goal of the Remedial Investigation for OU5 is to evaluate the extent to which the environmental media can serve as pathways for transporting contaminants. The Great Miami Aquifer is of particular concern since it may receive contaminants from the surface water and soil media.

Sampling Results of the RI

The results of the Remedial Investigation through 1990 for OU5 are summarized below. The data are presented by media.

Surface Water and Sediments

Surface water and sediment results were not available from 1990 RI/FS data. However, the reader may refer to Chapter Five, Liquid Pathway: Surface Water and Effluent Sampling for results of the Environmental Monitoring Program.

Soils

The RI sampling program for OU5 collected soils from the top six inches of soil for most onsite samples, and in the zero-to-one-inch zone for most offsite samples. The onsite samples showed total uranium concentrations between 1.5 and 63.6 pCi/g; the offsite samples registered between 2.7 and 51.2 pCi/g.

Soil data indicate that the potential areas of concern for uranium based on the 35 pCi/g criterion are largely limited to locations within the Production Area. Data also indicate that the high concentrations outside the production area are local and do not represent a significant area of concern.

Flora and Fauna

Based on RI sampling, local produce had no higher uranium concentrations than produce from an upwind control area. These results indicate that local produce was probably not a significant pathway for human exposure to uranium derived from FMPC operations. Milk sampling produced similar results. Vegetation sampling showed total uranium concentrations ranging from nondetectable to 35.5 pCi/g, occurring at detectable levels in about 62% of the samples.

In sampling small mammals, uranium was detected only in a composite sample of organs from animals collected near Waste Pit 5. No other radionuclides were detected.

Aquatic organisms could be exposed to FMPC radionuclides in wetlands, Paddy's Run, and the Great Miami River. The radioactive analysis of aquatic vegetation revealed the following:

- **Total uranium** – Concentrations ranged from nondetectable to 31.1 pCi/g, occurring at detectable levels in 44% of the samples.
- **Strontium-90** – Strontium-90 was detected once at 0.9 pCi/g.
- **Technetium-99** – Technetium-99 was detected once at 1.9 pCi/g.

Bottom-dwelling shellfish collected from Paddy's Run and the Great Miami River had detectable concentrations of uranium-234 and uranium-238. The results indicate that uranium may be entering the aquatic food chain. Concentrations for the contaminants detected were:

- **Uranium-234** – Concentrations ranging from 1.5 to 6.5 pCi/g.
- **Uranium-238** – Concentrations ranging from 1.5 to 6.5 pCi/g.

Fish collected from Paddy's Run had detectable levels of uranium (0.6 to 3.7 pCi/g) in 30% of the samples analyzed; no detectable radionuclides were found in fish samples from any site on the Great Miami River. Since fish samples did not have radionuclide concentrations higher than the shellfish, there is no evidence that radionuclides are accumulating in the food chain.

There is no evidence that threatened or endangered species are currently at risk from radionuclides or hazardous substances released by the FMPC.

Ambient Air

All available air data will be documented as part of the RI and will be considered as a pathway within the risk assessment. Air sampling results from the 1990 Environmental Monitoring Program may be found in Chapter Four of this report.

Groundwater

The groundwater RI program for OU5 focuses on determining the effect that the FMPC operations and waste disposal practices have had (and may continue to have) on the Great Miami Aquifer. The overall objectives of the groundwater program are to:

- Determine if subsurface water-bearing zones of the Great Miami Aquifer have been contaminated both beneath and off the FMPC property;
- Determine the source areas of contaminants at the FMPC and define areas of subsurface contaminant migration and groundwater discharge;
- Characterize the rate and direction of groundwater flow and contaminant transport within each hydrogeologic unit; and
- Determine the effects groundwater pumping and resulting recharge-discharge relationships have on groundwater flow and contaminant transport.

Groundwater data collected prior to the RI/FS indicated contamination in the aquifer in the area immediately downgradient and east of the waste storage pits. Analysis of samples from wells south of the FMPC also showed elevated levels of uranium. Data from additional rounds of

sampling indicated the location and boundaries of the plumes, determined the extent of vertical migration, and delineated source areas. Available data supported the interpretation that the principal source of the plumes was centered in the vicinity of the confluence of the Storm Sewer Outfall Ditch with Paddy's Run, the inactive and active fly ash piles, and the Southfield Disposal Area. Federal and state regulations required that the extent of elevated levels of uranium in groundwater south of the FMPC be defined.

Sampling indicates that two well-defined uranium plumes are present in the Great Miami Aquifer. One appears to originate under the Waste Storage Area and is moving to the east; contamination appears to be due to continuing releases. The other plume, the South Plume, appears to originate along Paddy's Run and the Storm Sewer Outfall Ditch (probably due to historic releases) and extends south of the FMPC property. It is the subject of a major removal action.

There were no known users during 1990 of groundwater as a potable water source from those areas of the aquifer with uranium concentrations above the level of concern. The only known use of this groundwater is for industrial purposes. No person in the vicinity of the FMPC is currently known to be at risk due to using water from the regional aquifer.

Influences on the quality of the groundwater can come from sources other than the FMPC. Certain constituents are common contaminants in rural areas due to agricultural activities and septic systems. Also, several industrial facilities are located south of the FMPC along Paddy's Run Road. The Paddy's Run Road site RI is currently underway to investigate whether these facilities are contributing contamination to the aquifer, Paddy's Run, and the Great Miami River.

South Groundwater Contamination Plume Removal Action

Groundwater was shown to be the only significantly contaminated medium. Acting on the potential that contamination in OU5 is an immediate threat to health and the environment, a removal action has begun. Consistent with removal action commitments in the Consent Agreement, an EE/CA for the South Plume was completed in November 1990.

The objectives of the removal action are to:

- Protect public health by limiting access to and use of contaminated groundwater;
- Protect the groundwater environment; and
- Control plume migration toward additional receptors farther south.

Based on these objectives, the following four alternatives have been developed for the South Groundwater Contamination Plume Removal Action:

Alternative 1 – No action.

Alternative 2 – Groundwater monitoring and institutional controls.

Alternative 3 – Alternate water supply, groundwater monitoring, and institutional controls.

Alternative 4 – Groundwater pumping and discharge, equivalent uranium removal from existing FMPC wastewater discharges, alternate water supply, groundwater monitoring, and institutional controls.

Alternative 4 is the removal action alternative selected that most comprehensively satisfies the evaluation criteria of effectiveness, implementability, and cost. The FMPC will begin implementing this alternative in late 1991.

Feasibility Study

As of 1990, the Feasibility Study for OU5 had not begun. Much of the data requirements that will govern OU5, such as contaminants of concern, exposure pathways and receptors, and acceptable cleanup levels, are still being defined.

SUMMARY OF THE REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

By 1990, some Remedial Investigation sampling results were available from each of the five operable units. Groundwater was shown to be the media most-threatened by FMPC activities. Accordingly, removal actions have begun for Operable Units 1, 3, and 5 to immediately reduce contamination and to prevent further contamination of the groundwater. Another removal action has been planned for OU4 to reduce radon concentration in the air from the K-65 Silos.

Results from the RI sampling at each OU will be used to evaluate Feasibility Study alternatives in the next major part of the RI/FS. This RI/FS work will continue through the decade.

APPENDICES

APPENDIX A

FMPC Environmental Monitoring Data for 1990

The FMPC designed and conducted numerous sampling and analysis procedures to evaluate compliance with environmental regulations and to obtain accurate indications of the effects of the facility's operations on the environment during 1990. The sampling and analysis results are provided in summary tables.

Many of the numerical values listed in the following data tables are preceded by the "less than" symbol (<). The less than symbol is used when the concentration of a chemical species (ion, molecule, compound, or radionuclide) in an environmental media (air, water, or sediment) could not be reliably measured in the sample which was analyzed. That is, the amount of the species, if present at all in the sample, was below the minimum measurable concentration. Thus a value of < 0.68 pCi/L listed as the concentration of uranium in milk means that the uranium concentration was less than 0.68 pCi/L, but could actually have been anywhere from 0.00 to 0.67 pCi/L.

The minimum measurable concentration is not the same for all chemical species. For example, 0.25 pCi/g of radium-226 and 0.021 pCi/g of plutonium-238 are the approximate minimum measurable concentrations for sediment samples. These variations exist because of differences in chemical and physical properties of species in addition to differences in the capabilities of instruments available to measure these properties.

Also, the minimum measurable concentration is not always the same for a specific species in all samples of the same environmental media. That is, the minimum measurable concentration for uranium in groundwater samples may vary for water samples from two different locations. This is so because variations in the kinds or amounts of other substances in the two samples can influence how well a substance can be measured.

In addition, the minimum measurable concentration of a species will not always be the same for identical samples from the same location which are analyzed at different times. This occurs because of unavoidable minor fluctuations from time to time in the performance of analytical instrumentation used to perform sample measurements.

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TABLE 1: Uranium in Air, 1990

Sampling Location [a]	Number of Samples	Concentration ($pCi/m^3 \times 10^{-6}$)			Percent of Standard [b]		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Fenceline							
AMS 1	52	0.00	490	150	0.00	0.49	0.15
AMS 2	52	0.00	350	140	0.00	0.35	0.14
AMS 3	52	0.00	1,700	240	0.00	1.7	0.24
AMS 4	52	0.00	230	87	0.00	0.23	0.087
AMS 5	52	0.00	440	91	0.00	0.44	0.091
AMS 6	52	0.00	320	120	0.00	0.32	0.12
AMS 7	52	0.00	520	89	0.00	0.52	0.089
Onsite							
AMS 8	52	0.00	1,330	360	0.00	1.3	0.36
AMS 9	52	80	4,600	1,300	0.08	4.6	1.3
Offsite							
AMS 10	50	0.00	220	57	0.00	0.22	0.057
AMS 11	50	0.00	150	40	0.00	0.15	0.040
AMS 12	51	0.00	480	42	0.00	0.48	0.042
AMS 13	50	0.00	230	58	0.00	0.23	0.058
AMS 14	51	0.00	440	44	0.00	0.44	0.044
AMS 15	51	0.00	370	51	0.00	0.37	0.051
AMS 16	52	0.00	350	57	0.00	0.35	0.057

(a) See Figure 15 for locations.

(b) Standard is 100,000 x 10^{-6} pCi/m^3, as listed in DOE Order 5400.5, February 1990.

TABLE 2: Radionuclides in Air, 1990

	Concentration [a,b] (pCi/m^3 x 10^{-6})					
	Strontium–90	Technetium–99	Ruthenium–106	Cesium–137	Radium–226	Radium–228
Derived Concentration Guide [c] pCi/m^3 x 10^{-6}	9,000,000	2,000,000,000	30,000,000	400,000,000	1,000,000	3,000,000
Sampling Location [d]						
AMS 1	1.6 ± 0.5	< 89	< 290	< 34	< 1.1	< 10
AMS 2	1.3 ± 0.4	< 100	< 525	< 42	< 1.6	< 12
AMS 3	2.4 ± 0.5	< 74	< 230	< 34	< 1.2	< 8.8
AMS 4	1.9 ± 0.5	< 77	< 410	< 59	< 0.8	< 8.0
AMS 5	< 0.71	95 ± 61	< 290	< 39	< 1.2	< 11
AMS 6	3.8 ± 0.7	< 110	< 370	< 29	< 1.6	< 8.9
AMS 7	2.9 ± 0.5	< 100	< 490	< 40	< 1.0	< 12
AMS 8	10 ± 1.2	< 110	< 480	< 39	1.7 ± 1.2	< 14
AMS 9	4.1 ± 0.6	< 95	< 580	< 59	< 1.6	< 9.8
AMS 10	< 9.5	< 140	< 1,500	< 11	21 ± 3.9	< 7.9
AMS 11	7.8 ± 1.8	< 150	< 1,400	< 15	5.1 ± 1.9	< 16
AMS 12	10.7 ± 1.9	< 190	< 1,400	< 17	3.5 ± 1.0	< 27
AMS 13	8.0 ± 1.6	< 130	< 1,400	< 13	5.4 ± 1.9	< 23
AMS 14	< 12.6	< 150	< 1,400	< 14	8.7 ± 2.2	< 10
AMS 15	8.6 ± 2.0	< 160	< 1,500	< 14	4.7 ± 1.4	< 25
AMS 16	10.5 ± 2.1	< 140	< 1,400	< 18	1.9 ± 1.2	< 13

TABLE 2: Radionuclides in Air, 1990

	Concentration [a,b] (pCi/m^3 x 10^{-6})				
	Thorium–228	Thorium–230	Thorium–232	Neptunium–237	Plutonium–238
Derived Concentration Guide [c] pCi/m^3 x 10^{-6}	40,000	40,000	7,000	20,000	30,000
Sampling Location [d]					
AMS 1	< 3.7	< 3.7	< 3.7	< 0.5	< 1.0
AMS 2	< 2.6	< 2.6	< 2.6	< 0.9	< 1.1
AMS 3	3.0 ± 1.9	3.0 ± 1.9	< 2.4	< 1.0	< 1.0
AMS 4	< 3.5	< 3.5	< 3.5	< 1.0	< 1.2
AMS 5	< 4.2	< 4.2	< 4.2	< 1.4	< 1.1
AMS 6	< 5.8	6.9 ± 4.5	< 5.8	< 0.7	< 1.0
AMS 7	3.5 ± 3.2	6.7 ± 3.9	< 4.7	< 0.5	< 1.0
AMS 8	< 8.9	11 ± 7	< 8.9	< 0.4	< 1.0
AMS 9	< 3.6	< 3.6	< 3.6	< 0.9	< 1.0
AMS 10	4.9 ± 3.3	4.9 ± 3.3	< 4.1	< 0.3	< 0.8
AMS 11	37 ± 7.5	< 2.6	< 2.6	< 0.8	< 0.9
AMS 12	36 ± 7.4	3.3 ± 2.0	< 2.5	< 0.8	< 0.9
AMS 13	26 ± 5.9	< 2.6	< 2.6	< 0.7	< 0.7
AMS 14	35 ± 6.9	3.9 ± 2.0	< 2.3	< 0.9	< 0.8
AMS 15	13 ± 4.8	10.4 ± 4.3	< 4.0	< 1.7	< 0.9
AMS 16	30 ± 7.1	5.9 ± 3.0	< 3.3	0.6 ± 0.6	< 0.7

TABLE 2: Radionuclides in Air, 1990

	Concentration [a,b] (pCi/m^3 x 10^{-6})				
	Plutonium–239/240	Uranium–234	Uranium–235	Uranium–236	Uranium–238
Derived Concentration Guide [c] pCi/m^3 x 10^{-6}	20,000	90,000	100,000	100,000	100,000
Sampling Location [d]					
AMS 1	< 0.8	68 ± 36	3.2 ± 0.4	1.7 ± 0.8	73 ± 9.3
AMS 2	< 1.1	27 ± 14	3.0 ± 0.4	1.0 ± 0.5	71 ± 9.0
AMS 3	< 1.0	130 ± 68	4.8 ± 0.7	2.2 ± 1.0	120 ± 15
AMS 4	< 0.9	39 ± 21	1.8 ± 0.2	0.7 ± 0.3	42 ± 5.4
AMS 5	< 0.9	33 ± 17	1.8 ± 0.3	0.4 ± 0.2	44 ± 5.6
AMS 6	< 1.0	33 ± 17	2.6 ± 0.4	0.8 ± 0.4	59 ± 7.5
AMS 7	< 1.0	39 ± 20	1.8 ± 0.3	0.6 ± 0.3	41 ± 5.2
AMS 8	< 1.0	390 ± 210	7.4 ± 0.1	6.8 ± 3.2	180 ± 22
AMS 9	< 1.0	340 ± 180	24 ± 3.3	11 ± 5	610 ± 77
AMS 10	< 0.8	118 ± 15.7	7.7 ± 2.7 [e]		117 ± 16
AMS 11	< 0.7	59 ± 9.1	4.4 ± 2.1		54 ± 8.5
AMS 12	< 0.7	51 ± 7.4	2.2 ± 1.3		47 ± 6.9
AMS 13	< 0.7	45 ± 6.9	3.3 ± 1.6		47 ± 7.2
AMS 14	< 0.8	120 ± 19	8.5 ± 4.0		114 ± 18
AMS 15	1.6 ± 1.0	59 ± 8.7	3.7 ± 1.8		59 ± 8.7
AMS 16	< 0.7	37 ± 6.1	2.1 ± 1.4		40 ± 6.5

(a) A composite of :
- *50 weekly samples at AMS 10, 11, and 13;*
- *51 weekly samples at AMS 14 and AMS 15;*
- *52 weekly samples at all other air monitoring sations.*

(b) Plus/minus (±) values are the uncertainty in the analytical results at the 95% confidence level.

(c) Derived concentration guides from DOE Order 5400.5, February, 1990. Continuous inhalation of this concentration will result in a committed effective dose equivalent of 100 mrem (1 mSv).

(d) See Figure 15 for sampling locations.

(e) Concentration of uranium-235 plus uranium-236. Offsite AMS samples analyzed for isotopic uranium by alpha spectrometry which measures combined uranium-235 and uranium-236 activities; individual measurements of uranium isotopes performed by mass spectrometry on samples from other AMS locations.

TABLE 3: Uranium in Soil & Grass and Fluoride in Grass, 1990

Sampling Location [a]	Distance from Center of FMPC (km)	Soil Uranium Concentration (pCi/g) [b,c] 0-5 cm	Soil Uranium Concentration (pCi/g) [b,c] 5-10 cm	Grass Uranium Concentration (pCi/g dry) [b,c]	Grass Fluoride Concentration (µg/g)
Onsite					
AMS 9	0.10	41 ± 6.2	20 ± 3.2	0.48 ± 0.07	2.0
AMS 8	0.15	9.5 ± 1.5	8.2 ± 1.4	0.041 ± 0.009	1.5
Fenceline					
AMS 1	0.16	8.4 ± 1.8	4.3 ± 1.2	0.0066 ± 0.0007	0.99
AMS 3	0.16	12 ± 1.8	16 ± 2.2	0.28 ± 0.04	1.5
AMS 4	0.49	6.4 ± 1.5	2.2 ± 0.9	0.070 ± 0.011	2.4
AMS 6	0.63	9.2 ± 1.8	7.4 ± 1.6	0.015 ± 0.002	1.7
AMS 5	0.64	< 2.9	8.4 ± 1.8	0.016 ± 0.002	1.4
AMS 2	1.1	15 ± 2.2	11 ± 1.8	0.0051 ± 0.0005	1.0
AMS 7	1.3	8.9 ± 2.0	4.7 ± 1.2	0.020 ± 0.002	1.0
Offsite					
30	1.3	7.2 ± 1.4	5.4 ± 1.2	0.0028 ± 0.0003	0.69
31	1.9	7.2 ± 1.5	6.8 ± 1.6	0.00029 ± 0.0004	1.2
15	1.9	6.3 ± 1.5	3.1 ± 1.0	0.0084 ± 0.0009	4.0
12	2.2	2.5 ± 1.1	3.3 ± 1.3	0.0028 ± 0.0003	1.2
24	2.4	6.4 ± 1.6	4.9 ± 1.8	< 0.00044	1.5
10	2.6	4.8 ± 1.5	3.2 ± 1.2	0.0033 ± 0.0004	1.0
25	2.7	4.2 ± 1.5	6.1 ± 1.6	0.00042 ± 0.00005	2.6
11	3.7	3.4 ± 1.4	3.8 ± 1.2	0.0021 ± 0.0002	0.62
17	3.7	3.4 ± 1.2	2.8 ± 1.2	< 0.00040	3.2
20	3.7	1.6 ± 0.7	1.9 ± 0.9	0.00059 ± 0.0001	1.4

TABLE 3: Uranium in Soil & Grass and Fluoride in Grass, 1990

Sampling Location [a]	Distance from Center of FMPC (km)	Soil Uranium Concentration (pCi/g) [b,c] 0-5 cm	Soil Uranium Concentration (pCi/g) [b,c] 5-10 cm	Grass Uranium Concentration (pCi/g dry) [b,c]	Grass Fluoride Concentration (µg/g)
Offsite, continued					
34	3.8	4.8 ± 1.5	2.4 ± 1.0	0.0040 ± 0.0005	0.80
21	3.9	3.4 ± 1.1	4.3 ± 1.4	< 0.00074	1.7
13	4.2	3.9 ± 1.2	2.6 ± 0.9	0.0019 ± 0.0002	1.4
33	4.2	2.6 ± 1.1	3.7 ± 1.4	< 0.00036	3.4
23	4.3	2.1 ± 1.1	5.1 ± 1.6	< 0.00034	2.3
22	5.0	4.5 ± 1.5	2.3 ± 1.1	0.0013 ± 0.0002	1.2
18	5.1	1.1 ± 0.8	1.5 ± 0.7	0.0030 ± 0.0003	1.6
14	5.4	2.4 ± 1.0	2.0 ± 1.1	< 0.00043	3.3
19	8.8	7.2 ± 1.4	5.4 ± 1.2	< 0.00061	4.6
29	24	2.4 ± 1.0	2.0 ± 1.1	insufficient sample for uranium analysis	1.1
28	40	1.1 ± 0.8	1.5 ± 0.7	< 0.00030	0.82

(a) Locations (see Figure 18) are listed in order of increasing distance from the center of the FMPC production area (Plant 4).

(b) To obtain Bq/g, multiply pCi/g by 0.037.

(c) The plus/minus (±) values are the uncertainity in the analytical results at the 95% confidence level.

TABLE 4: Uranium in Soil and Produce, 1990[a]

Distance from Center of FMPC (km)	Sampling Location [b]	Concentration (pCi/g dry) [c,d]
Soil		
1.0	9	3.5 ± 1.2
1.3	2	7.2 ± 1.6
1.4	10	4.0 ± 1.4
1.6	11	3.1 ± 1.3
1.6	14	1.5 ± 1.0
1.6	1	4.1 ± 1.2
1.8	3	Not Sampled
1.9	8	4.1 ± 1.4
2.1	5	3.7 ± 1.2
2.2	12	4.3 ± 1.2
2.4	6	3.3 ± 1.1
2.4	7	3.8 ± 1.5
2.9	13	2.4 ± 1.0
3.2	4	3.3 ± 1.2
6.1	17	2.2 ± 1.1
16	20	2.7 ± 1.1
18	19	2.7 ± 1.1
24	18	Not Sampled
30	16	2.2 ± 1.1
42	15	2.1 ± 1.0

	Sampling Location [b]	Concentration (pCi/g dry) [c,d]
Tomatoes		
	2	0.13 ± 0.02
	14	0.029 ± 0.006
	1	0.028 ± 0.003
	13	0.069 ± 0.009
	4	< 0.0040
	17	0.0078 ± 0.0016
	20	0.0064 ± 0.001
	19	0.0092 ± 0.0013
	18	0.024 ± 0.003
	16	0.027 ± 0.003
Cabbage (C), Mustard Green (MG), and Kale (K)		
	13 (C)	0.017 ± 0.002
	13 (MG)	0.022 ± 0.002
	4 (C)	0.0072 ± 0.001
	20 (K)	0.017 ± 0.003
Apples		
	2	0.0082 ± 0.0009
	1	0.013 ± 0.002
	20	0.0017 ± 0.0004
	19	0.0018 ± 0.0003

TABLE 4: Uranium in Soil and Produce, 1990[a]

	Sampling Location [b]	Concentration (pCi/g dry) [c,d]
Corn		
	10	0.032 ± 0.003
	11	0.0083 ± 0.0009
	1	0.0064 ± 0.0007
	8	0.20 ± 0.05
	5	0.080 ± 0.008
	6	0.0098 ± 0.0011
	7	0.015 ± 0.002
	15	0.0038 ± 0.0005
Potatoes (P), Sweet Potatoes (SP), Onions (O), Turnips (T), Radish (R), Carrots (C), and Beets (B)		
	2 (B)	< 0.0040
	14 (P)	0.012 ± 0.002
	1 (C)	< 0.0038
	3 (P)	0.016 ± 0.002
	4 (P)	0.029 ± 0.003
	4 (SP)	0.0062 ± 0.001
	20 (P)	0.068 ± 0.007
	19 (T)	0.074 ± 0.008
	16 (C)	0.030 ± 0.003
	16 (O)	0.047 ± 0.005
	16 (R)	0.0042 ± 0.0007
	16 (T)	0.092 ± 0.010
Soybeans		
	9	0.056 ± 0.006
	10	0.057 ± 0.007
	1	0.0035 ± 0.0006
	8	< 0.00011
	5	< 0.0024
	12	< 0.0023
	6	0.0054 ± 0.0008
	7	< 0.0023
	18	0.015 ± 0.002
	15	< 0.0024
Peppers (P) & Green Beans (GB)		
	2 (P)	0.013 ± 0.002
	14 (P)	0.016 ± 0.002
	14 (P)	0.027 ± 0.0036
	1 (P)	0.0070 ± 0.0011
	13 (P)	0.029 ± 0.004
	20 (GB)	0.018 ± 0.003
	16 (P)	0.018 ± 0.002

(a) Samples collected during September or October 1990.

(b) Locations (see Figure 19) are listed in order of increasing distance from the center of the FMPC production area (Plant 4).

(c) To obtain Bq/g, multiply pCi/g by 0.037.

(d) The plus/minus (±) values are the uncertainty in the analytical results at the 95% confidence level.

TABLE 5: Radionuclides in Milk, 1990

Month	Radionuclide	Concentration (pCi/L) [a]	
		Local Dairy	Background Dairy [b]
January	Uranium	< 0.68	< 0.68
February	Uranium	< 0.68	< 0.68
March	Uranium	0.0007	0.0007
April	Uranium	4.8 ± 0.6	3.7 ± 0.5
May	Uranium	11 ± 1.5	2.7 ± 0.4
June	Uranium	< 0.68	2.2 ± 0.3
July	Uranium	< 0.68	< 0.68
August	Uranium	< 0.68	< 0.68
September	Uranium	0.015 ± 0.002	0.045 ± 0.006
October	Uranium	0.10 ± 0.01	0.091 ± 0.010
November	Uranium	0.053 ± 0.006	0.046 ± 0.0077
December	Radium – 226	1.5 ± 0.4	0.35 ± 0.21
	Radium – 228	4.3 ± 1.8	< 3.8
	Strontium – 90	1.2 ± 0.2	1.2 ± 0.2
	Thorium – 228	3.8 ± 1.4	3.6 ± 1.3
	Thorium – 230	1.2 ± 0.9	< 0.98
	Thorium – 232	< 1.2	< 0.98
	Uranium – 234	1.9 ± 0.6	1.1 ± 0.4
	Uranium – 235/236	< 0.44	< 0.34
	Uranium – 238	1.7 ± 0.55	0.65 ± 0.31
	Total Uranium	0.061 ± 0.009	< 0.015

(a) To obtain Bq/L, multiply pCi/L by 0.037.

(b) Dairy is about 37 km (23 miles) WSW of the FMPC.

TABLE 6: Radon in Air, 1990

Fenceline Locations [a]	Concentration (pCi/L) [b] 1990	1989
AMS 1	0.4	0.6
AMS 2	0.6	0.7
AMS 4	0.4	0.7
AMS 6	0.6	0.9
AMS 7	0.5	0.6
FMPC A	1.1	0.8
FMPC B	0.7	0.8
FMPC C	0.5	0.7
FMPC D	0.5	0.5
FMPC E	0.7	0.7
FMPC F	0.5	0.7
FMPC G	0.8	0.8
FMPC H	1.5	0.6
FMPC I	1.1	0.7
FMPC J	1.2	0.5
FMPC K	0.7	1.0
FMPC L	0.6	0.8
FMPC M	0.7	0.8
FMPC N	0.8	0.8
FMPC O	0.7	0.8
FMPC P	0.9	1.0

Background Locations [a]	Concentration (pCi/L) [b] 1990	1989
BKGD 1	0.4	0.4
BKGD 2	0.4	0.6
AMS 15	0.6	— [c]
AMS 16	0.6	— [c]

Other Locations [a]	Concentration (pCi/L) [b] 1990	1989
AMS 8	0.5	0.6
AMS 9	0.6	0.8
AMS 10	0.5	0.9
AMS 11	0.6	0.6
AMS 12	0.7	0.6
AMS 13	0.7	0.7
RES 1	0.7	0.8
RES 2	0.6	0.9
RES 3	0.6	0.8

(a) See Figures 15, 20 and 21 for locations.

(b) To obtain Bq/L, multiply pCi/L by 0.037.

(c) 1990 was the first year samples were collected at these locations.

(d) DOE guideline is 3.0 pCi/L above-background as stated in DOE Order 5400.5, February 1990.

Summary: 1990 & 1989 Results

Average Fenceline Concentration Minus Average Background Concentration Equals Average Net Concentration

Fenceline (21 Locations)	Concentration (pCi/L) [b] 1990	1989
Average	0.75	0.74
Std. Dev.	± 0.27	± 0.14

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Background (4 Locations)	Concentration (pCi/L) [b] 1990	1989
Average	0.52	0.50
Std. Dev.	± 0.09	± 0.07

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Net Concentration at the Fenceline [d]	Concentration (pCi/L) [b] 1990	1989
Average	0.23	0.24
Std. Dev.	± 0.28	± 0.15

TABLE 7: Radionuclides Discharged to the Great Miami River, 1990

Radionuclide	Total Curies 1989	Total Curies 1990	1990 Average Concentration (pCi/L) [a,b]	Standard [c] pCi/L	Percent of Standard [d]
Actinium – 227	< 0.00094	< 0.00098	< 1.0	10	< 10.0
Cesium – 137	< 0.0074	< 0.0036	< 11	3,000	< 0.4
Lead – 210	< 0.0041	< 0.0083	< 8.5	30	< 28.2
Neptunium – 237	< 0.000090	< 0.00020	< 0.21	30	< 0.7
Potassium – 40	< 0.12	< 0.16	< 163	7,000	< 2.3
Plutonium – 238	< 0.00007	< 0.000098	< 0.10	40	< 0.3
Plutonium – 239/240	0.00010	< 0.00012	< 0.13	30	< 0.4
Radium – 226	< 0.0026	< 0.0048	< 4.9	100	< 4.9
Radium – 228	< 0.0058	< 0.010	< 10.6	100	< 10.6
Ruthenium – 106	< 0.067	< 0.030	< 90	6,000	< 1.5
Strontium – 90	< 0.00052	0.00014	0.40	1,000	0.04
Technetium – 99	< 3.3	< 1.7	< 1,690	100,000	< 1.7
Thorium – 228	< 0.0029	< 0.00027	< 0.3	400	< 0.08
Thorium – 230	0.00026	0.00069	0.7	300	0.2
Thorium – 232	0.00073	< 0.00050	< 0.5	50	< 1.0
Thorium – 234	0.28 [e]	0.26 [e]	267 [e]	10,000	2.7
Uranium – 234	0.22	0.18	185.4	500	37.1
Uranium – 235	0.011	0.011	11.1	600	1.9
Uranium – 236	0.0079	0.0068	7.0	500	1.4
Uranium – 238	0.28	0.26	267	600	44.6
					Sum of the Percentages: < 150.2

(a) Radionuclide concentrations in the plant effluent discharged to the Great Miami River are determined from monthly or quarterly composites of daily, 24-hour continuous samples at Outfall 001.

(b) To obtain Bq/L, multiply pCi/L by 0.037.

(c) As stated in DOE Order 5400.5, February 1990.

(d) Percent of standard relates to the average concentration.

(e) Calculated value based on radioactive decay equilibrium with uranium – 238.

TABLE 8: Radionuclides in Surface Water, 1990
Great Miami River

Parameter	Sampling Location [a]	Number of Samples	Concentration (pCi/L) [b] Minimum	Maximum	Average	Standards (pCi/L) [c]	Percent of Standard Minimum	Maximum	Average
Total Uranium									
Upstream of Effluent Line	W1	52	0.81	2.0	1.2	550	0.15	0.36	0.22
Downstream of Effluent Line	W3	49	0.88	2.0	1.4	550	0.16	0.37	0.25
Downstream of Effluent Line	W4	46	0.81	1.8	1.3	550	0.15	0.32	0.23
Radium – 226 [d]									
Upstream of Effluent Line	W1	12	< 0.10	0.36	0.24	100	< 0.10	0.36	0.24
Downstream of Effluent Line	W3	12	0.10	0.37	0.21	100	0.10	0.37	0.21
Downstream of Effluent Line	W4	12	< 0.10	0.38	0.19	100	< 0.10	0.38	0.19
Radium – 228 [d]									
Upstream of Effluent Line	W1	12	0.49	5.1	< 1.8	100	0.49	5.1	< 1.8
Downstream of Effluent Line	W3	12	0.49	< 2.0	< 1.4	100	0.49	< 2.0	< 1.4
Downstream of Effluent Line	W4	12	0.42	< 2.0	< 1.3	100	0.42	< 2.0	< 1.3
Strontium – 90 [d]									
Upstream of Effluent Line	W1	2	0.25	1.2		1,000	0.025	0.12	
Downstream of Effluent Line	W3	2	0.22	1.6		1,000	0.022	0.16	
Downstream of Effluent Line	W4	2	0.37	0.37		1,000	0.037	0.037	
Cesium – 137 [d]									
Upstream of Effluent Line	W1	2	< 4.7	< 6.6		3,000	< 0.16	< 0.22	
Downstream of Effluent Line	W3	2	< 8.0	< 11		3,000	< 0.27	< 0.37	
Downstream of Effluent Line	W4	2	< 6.2	< 8.8		3,000	< 0.21	< 0.29	
Technetium – 99 [d]									
Upstream of Effluent Line	W1	2	< 15	< 18		100,000	< 0.015	< 0.018	
Downstream of Effluent Line	W3	2	< 15	< 15		100,000	< 0.015	< 0.015	
Downstream of Effluent Line	W4	2	< 16	< 18		100,000	< 0.016	< 0.018	

TABLE 8: Radionuclides in Surface Water, 1990
Paddy's Run

Parameter	Sampling Location [a]	Number of Samples	Concentration (pCi/L) [b] Minimum	Maximum	Average	Standards (pCi/L) [c]	Percent of Standard Minimum	Maximum	Average
Total Uranium									
Upstream of FMPC	W5	52	0.68	1.1	0.75	550	0.01	0.20	0.14
Onsite	W9	51	0.88	2.8	1.5	550	0.16	0.52	0.27
Onsite	W10	44	1.1	1,100	76	550	0.20	200	14
Onsite	W11	38	1.4	81	8.9	550	0.24	15	1.6
Downstream of FMPC	W7	36	2.6	53	6.5	550	0.47	9.7	1.2
Downstream of FMPC	W8	20	1.4	26	4.5	550	0.25	4.7	0.82
Radium – 226 [d]									
Upstream of FMPC	W5	6	0.078	0.58	0.25	100	0.078	0.58	0.25
Downstream of FMPC	W7	9	0.00061	0.49	0.15 [e]	100	0.00061	0.49	0.15 [e]
Downstream of FMPC	W8	3	0.034	< 0.15	0.052	100	0.034	< 0.15	0.052
Radium – 228 [d]									
Upstream of FMPC	W5	6	0.89	< 2.0	< 1.5	100	0.89	< 2.0	< 1.5
Downstream of FMPC	W7	9	1.0	< 2.0	< 1.7	100	1.0	< 2.0	< 1.7
Downstream of FMPC	W8	3	0.77	1.2	0.8	100	0.77	1.2	0.8

(a) See Figure 29 for sampling locations.

(b) To obtain Bq/L, multiply pCi/L by 0.037.

(c) Standards as listed in DOE Order 5400.5, February 1990. The standards are based on drinking 730 liters (about 200 gallons) of water per year. The FMPC compares data from the Great Miami River and Paddy's Run to these standards even though neither is designated as a public water supply by OEPA (OEPA Regulations, Vol. 1, 3475-1-21).

(d) Samples are composited as follows:
- *one-month composites of daily samples from W1 and W3;*
- *one-month composites of weekly samples from W4;*
- *two-month composites of weekly samples from W5; and*
- *one-month composites of all available weekly samples from W7 and W8.*

Semiannual composites were used for those isotopes where two samples are recorded.

(e) Represents the median value.

TABLE 9: Radioisotopes in Great Miami River, Paddy's Run, and Storm Sewer Outfall Ditch Sediments, 1990

Paddy's Run above Storm Sewer Outfall Ditch[a]

Radionuclide	Number of Samples	Number of Nondetectables	Percent Nondetectable	Concentration (pCi/g dry) [b] Minimum	Maximum	Max. to Min. Ratio	Average for all Occurances
Plutonium – 238	70	64	91.4 %	< 0.021	0.22	10.4	< 0.059
Plutonium – 239/240	70	57	81.4 %	< 0.014	0.28	20.2	< 0.060
Radium – 224	70	0	0.0 %	0.26	2.3	8.7	0.57
Radium – 226	70	1	1.4 %	< 0.25	3.7	14.6	0.89
Radium – 228	70	3	4.3 %	< 0.18	2.0	11.1	0.54
Technetium – 99	70	69	98.6 %	< 0.53	< 1.2	2.3	< 0.71
Thorium – 228	70	12	17.1 %	0.28	5.1	18.4	1.3
Thorium – 230	70	18	25.7 %	0.27	9.8	35.9	1.1 [c]
Thorium – 232	70	22	31.4 %	0.19	5.4	28.1	0.75 [c]
Uranium – 234	70	5	7.1 %	0.41	10	24.2	0.86 [c]
Uranium – 235/236	70	67	95.7 %	< 0.075	< 2.6	34.7	< 0.72
Uranium – 238	70	10	14.3 %	< 0.46	8.7	18.8	1.4

Storm Sewer Outfall Ditch[a]

Radionuclide	Number of Samples	Number of Nondetectables	Percent Nondetectable	Concentration (pCi/g dry) [b] Minimum	Maximum	Max. to Min. Ratio	Average for all Occurances
Plutonium – 238	21	19	90.5 %	< 0.023	0.13	5.5	< 0.051
Plutonium – 239/240	21	17	81.0 %	< 0.019	< 0.11	5.8	< 0.042
Radium – 224	21	0	0.0 %	0.30	1.7	5.7	0.63
Radium – 226	21	0	0.0 %	0.41	1.3	3.1	0.72
Radium – 228	21	0	0.0 %	0.29	1.7	5.9	0.61
Technetium – 99	21	21	100.0 %	< 0.56	< 0.97	1.7	< 0.70
Thorium – 228	21	0	0.0 %	0.51	1.8	3.5	0.90
Thorium – 230	21	0	0.0 %	0.30	3.4	11.1	1.3
Thorium – 232	21	0	0.0 %	0.27	2.1	7.7	0.60
Uranium – 234	21	2	9.5 %	0.74	7.6	10.3	2.1
Uranium – 235/236	21	13	61.9 %	< 0.08	1.6	19.0	< 0.38
Uranium – 238	21	2	9.5 %	0.65	7.5	11.5	2.2

TABLE 9: Radioisotopes in Great Miami River, Paddy's Run, and Storm Sewer Outfall Ditch Sediments, 1990

Paddy's Run below Storm Sewer Outfall Ditch[a]

Radionuclide	Number of Samples	Number of Nondetectables	Percent Nondetectable	Concentration (pCi/g dry) [b] Minimum	Maximum	Max. to Min. Ratio	Average for all Occurances
Plutonium – 238	54	37	68.5 %	< 0.019	0.090	4.7	< 0.047
Plutonium – 239/240	54	50	92.6 %	< 0.019	< 0.12	6.3	< 0.044
Radium – 224	54	0	0.0 %	0.237	1.1	4.7	0.51
Radium – 226	54	0	0.0 %	0.44	1.2	2.6	0.70
Radium – 228	54	0	0.0 %	0.25	0.95	3.8	0.46
Technetium – 99	54	53	98.1 %	< 0.58	< 0.97	1.7	< 0.77
Thorium – 228	54	0	0.0 %	0.27	1.3	4.6	0.58
Thorium – 230	54	0	0.0 %	0.21	1.8	8.5	0.84
Thorium – 232	54	6	11.1 %	0.13	1.1	8.8	0.44
Uranium – 234	54	0	0.0 %	0.49	29	58.6	0.83 [c]
Uranium – 235/236	54	32	59.3 %	< 0.067	3.4	50.9	< 0.26
Uranium – 238	54	0	0.0 %	0.41	30	72.7	0.81 [c]

Great Miami River above Effluent Line[a]

Radionuclide	Number of Samples	Number of Nondetectables	Percent Nondetectable	Concentration (pCi/g dry) [b] Minimum	Maximum	Max. to Min. Ratio	Average for all Occurances
Plutonium – 238	3	3	100.0 %	< 0.014	< 0.11	7.9	< 0.054
Plutonium – 239/240	3	3	100.0 %	< 0.014	< 0.043	3.1	< 0.032
Radium – 226	3	0	0.0 %	0.64	0.68	1.1	0.67
Radium – 228	3	0	0.0 %	0.48	0.56	1.2	0.51
Technetium – 99	3	3	100.0 %	< 0.54	< 0.69	1.3	< 0.64
Thorium – 228	3	0	0.0 %	1.3	1.5	1.1	1.4
Thorium – 230	3	0	0.0 %	0.91	1.2	1.3	1.0
Thorium – 232	3	0	0.0 %	0.42	0.60	1.4	0.52
Uranium – 234	3	0	0.0 %	0.74	1.2	1.7	0.93
Uranium – 235/236	3	1	33.3 %	< 0.11	0.38	3.4	0.20
Uranium – 238	3	0	0.0 %	0.70	1.0	1.4	0.83

TABLE 9: Radioisotopes in Great Miami River, Paddy's Run, and Storm Sewer Outfall Ditch Sediments, 1990

Great Miami River below Effluent Line, above Paddy's Run[a]

Radionuclide	Number of Samples	Number of Nondetectables	Percent Nondetectable	Concentration (pCi/g dry) [b] Minimum	Maximum	Max. to Min. Ratio	Average for all Occurances
Plutonium – 238	4	4	100.0 %	< 0.037	< 0.076	2.1	< 0.055
Plutonium – 239/240	4	4	100.0 %	< 0.027	< 0.10	3.7	< 0.046
Radium – 226	4	0	0.0 %	0.53	0.84	1.6	0.71
Radium – 228	4	0	0.0 %	0.42	0.82	1.9	0.60
Technetium – 99	4	4	100.0 %	< 0.61	< 0.69	1.1	< 0.65
Thorium – 228	4	0	0.0 %	1.1	1.4	1.3	1.2
Thorium – 230	4	0	0.0 %	0.75	1.3	1.7	1.0
Thorium – 232	4	0	0.0 %	0.29	0.57	2.0	0.47
Uranium – 234	4	0	0.0 %	0.65	1.5	2.3	0.93
Uranium – 235/236	4	3	75.0 %	< 0.088	< 0.38	4.3	< 0.20
Uranium – 238	4	0	0.0 %	0.58	1.6	2.7	0.89

Great Miami River below Paddy's Run[a]

Radionuclide	Number of Samples	Number of Nondetectables	Percent Nondetectable	Concentration (pCi/g dry) [b] Minimum	Maximum	Max. to Min. Ratio	Average for all Occurances
Plutonium – 238	2	2	100.0 %	< 0.031	< 0.033	1.1	< 0.032
Plutonium – 239/240	2	2	100.0 %	< 0.031	< 0.085	2.7	< 0.058
Radium – 226	2	0	0.0 %	0.54	0.93	1.7	0.73
Radium – 228	2	0	0.0 %	0.46	0.63	1.4	0.54
Technetium – 99	2	2	100.0 %	< 0.69	< 0.71	1.0	< 0.70
Thorium – 228	2	0	0.0 %	1.0	1.3	1.3	1.1
Thorium – 230	2	0	0.0 %	0.95	1.1	1.1	1.0
Thorium – 232	2	0	0.0 %	0.47	0.62	1.3	0.55
Uranium – 234	2	0	0.0 %	0.76	0.77	1.0	0.77
Uranium – 235/236	2	2	100.0 %	< 0.081	< 0.089	1.1	< 0.085
Uranium – 238	2	0	0.0 %	0.77	0.81	1.1	0.79

(a) See Figure 31 for sample location.

(b) Multiply pCi/g by 0.037 to obtain Bq/g.

(c) Represents the median value.

TABLE 10: Uranium in Fish from the Great Miami River, 1990

Sampling Location [a]	Family [b]	Number of Samples	Concentration (pCi/g dry) [c] Minimum	Maximum	Average
1	1	0			
Upstream of	2	11	0.0038	0.11	0.022
the Effluent Line	3	5	0.017	0.042	0.0032
(River Mile 28)	4	9	0.035	0.60	0.12
	5	0			
	Summary	**25**	**0.0038**	**0.60**	**0.059**
2	1	1		0.021	
At the Effluent Line	2	8	0.0022	0.010	0.0047
(River Mile 24)	3	4	0.0050	0.014	0.0070
	4	6	0.0096	0.015	0.013
	5	1		0.014	
	Summary	**20**	**0.0022**	**0.021**	**0.0084**
3	1	5	0.0065	0.022	0.014
Confluence	2	8	0.0058	0.021	0.011
of Paddy's Run	3	2	0.0030	0.013	0.0079
and River	4	17	0.0035	0.027	0.019
(River Mile 19)	5	3	0.013	0.021	0.016
	Summary	**35**	**0.0030**	**0.027**	**0.016**
4	1	3	0.0068	0.062	0.028
Downstream of	2	1		0.060	
the Effluent Line near	3	3	0.015	0.028	0.020
Shawnee Lookout	4	9	0.018	0.087	0.043
County Park	5	1		0.066	
(River Mile 1.2)	**Summary**	**17**	**0.0068**	**0.087**	**0.039**

TABLE 10: Uranium in Fish from the Great Miami River, 1990

Sampling Location [a]	Family [b]	Number of Samples	Concentration (pCi/g dry) [c] Minimum	Maximum	Average
5	1	4	0.0031	0.12	0.035
Confluence	2	1		0.0055	
of Ohio and	3	1		0.0085	
Great Miami Rivers	4	4	0.0033	0.012	0.0082
(River Mile 0.0)	5	0			
	Summary	**10**	**0.0031**	**0.12**	**0.019**

(a) See Figure 32 for sampling locations.

(b) Family:
1 = Cyprinidae (carp)
2 = Catastomidae (carpsucker, redhorse, quillback, buffalo)
3 = Centrarchidae, Sciaenidae (bass, drum, sauger) and Lepisosteidae (gar)
4 = Clupeidae (gizzard shad)
5 = Ictaluridae (catfish)

(c) To obtain Bq/g, multiply pCi/g by 0.037.

TABLE 11A: NPDES Data for January – February, 1990

Sampling Location and Parameter	Units	Monitoring Requirements	Daily Monitoring Results Minimum	Maximum	Average (a)	Permit Limits (b) Daily Maximum	Monthly Average	Percent Compliance (c)
Manhole–175 to the Great Miami River *(Outfall 001)*								
Flow Rate	MGD	Continuous	0.22	1.4	0.73	NA	NA	NA
pH	S.U.	Daily/Grab	7.6	9.0	NA	Range = 6.5 to 9.0		100.0
Suspended Solids (d)	mg/L	Wk/24hr Comp	7	62	27	40	20	72.7
Oil & Grease	mg/L	Weekly/Grab	< 5	< 5	< 5	15	NA	100.0
Residual Chlorine	mg/L	Weekly/Grab	0.02	0.06	0.03	0.1	NA	100.0
						Percent Compliance for Discharges to the Great Miami River		***96.6***
Spillway to Paddy's Run *(Outfall 002)*								
Flow Rate	MG/Event	Continuous	The Stormwater Retention Basin did not overflow during this period.					
pH	S.U.	Event/Grab						
Suspended Solids (d)	mg/L	Event/Grab						
Oil & Grease	mg/L	Event/Grab						
						Percent Compliance for Discharges to Paddy's Run		***NA***
Sewage Treatment Plant *(Outfall 001 A)*								
Flow Rate	MGD	Continuous	0.10	0.37	0.23	NA	NA	NA
pH	S.U.	Daily/Grab	7.5	8.4	NA	Range = 6.5 to 9.0		100.0
Fecal Coliform	#Col/100mL	Weekly/Grab	3	960	28 (e)	2,000	1,000 (e)	100.0
Suspended Solids (d)	mg/L	Wk/24hr Comp	2.4	9.6	6.7	40	20	100.0
BOD,5	mg/L	Weekly/Grab	2.0	5.0	2.4	40	20	100.0
Suspended Solids	kg/day	Wk/24hr Comp	2.0	9.9	5.9	10	5	90.9
BOD,5	kg/day	Weekly/Grab	1.3	3.5	2.1	10	5	100.0
						Percent Compliance for Sewage Treatment Plant Discharges		***99.1***

TABLE 11A: NPDES Data for January – February, 1990

Sampling Location and Parameter	Units	Monitoring Requirements	Daily Monitoring Results Minimum	Maximum	Average (a)	Permit Limits (b) Daily Maximum	Monthly Average	Percent Compliance (c)
Combined General Sump & Clearwell *(Outfall 001 B&C)*								
Flow Rate	MGD	Continuous	0.022	0.12	0.059	NA	NA	NA
Suspended Solids	kg/day	Wk/24hr Comp	0.2	6.2	1.5	13	6.2	100.0
Chromium (total)	kg/day	Wk/24hr Comp	< 0.0002	0.0008	< 0.0004	0.10	0.050	100.0
Chromium (+6)	kg/day	Wk/24hr Comp	< 0.0002	0.0017	< 0.0005	0.008	0.004	100.0
Copper	kg/day	Wk/24hr Comp	0.0005	0.0017	0.0010	0.051	0.025	100.0
Nickel	kg/day	Wk/24hr Comp	0.0003	0.0013	0.0009	0.26	0.12	100.0
Iron	kg/day	Wk/24hr Comp	0.0057	0.37	0.079	0.85	0.41	100.0
						Percent Compliance for General Sump and Clearwell Discharges		***100.0***
Lift Station *(Outfall 001 D)*								
Flow Rate	MGD	Continuous	0.066	0.59	0.17	NA	NA	NA
Suspended Solids (d)	mg/L	Weekly/Grab	< 2	140	50	100	30	81.8
Oil & Grease	mg/L	Weekly/Grab	< 5	6	< 5	15	NA	100.0
						Percent Compliance for Lift Station Discharges		***90.0***
Bioreacter *(Outfall 001 E)*								
Flow Rate	MGD	Continuous	0.029	0.16	0.10	NA	NA	NA
Nitrate – Nitrogen	kg/day	Wk/24hr Comp	0.03	0.18	0.10	120	62	100.0
Ammonia – Nitrogen	kg/day	Wk/24hr Comp	0.07	0.32	0.18	18	12	100.0
						Percent Compliance for Bioreactor Discharges		***100.0***
						Percent Compliance for all Discharges		***98.0***

(a) Daily Average is shown as less than (<) if more than one quarter of the values were less than the detection limit.

(b) Values have been rounded for consistency of data presentation.

(c) Percent compliance is determined by comparing the noncompliances with the compliance opportunities.

(d) Flow-weighted averages.

(e) Geometric mean.

TABLE 11B: NPDES Data for March – December, 1990

Sampling Location and Parameter	Units	Monitoring Requirements	Daily Monitoring Results Minimum	Maximum	Average (a)	Permit Limits (b) Daily Maximum	Monthly Average	Percent Compliance (c)
Manhole–175 to Great Miami River *(Outfall 001)*								
Flow Rate	MGD	Continuous	0.078	1.6	0.71	NA	NA	NA
pH	S.U.	Continuous	4.3	10	NA	Range = 6.5 to 9.0		96.8
Dissolved Oxygen	mg/L	Weekly/Grab	5.0	14	9.2	Minimum = 5.0		100.0
Suspended Solids	mg/L	Wk/24hr Comp	< 2.0	39	7.7	45	30	100.0
BOD, C	mg/L	Wk/24hr Comp	0.6	12	2.7	30	20	100.0
Oil & Grease	mg/L	Weekly/Grab	< 5.0	< 5.0	< 5.0	15	15	100.0
Cyanide	mg/L	Weekly/Grab	< 0.005	< 0.005	< 0.005	0.076	0.036	100.0
Copper	µg/L	Wk/24hr Comp	< 4.9	42	< 13	94	23	100.0
Silver	µg/L	Wk/24hr Comp	< 1.0	3.0	< 2.2	26	12	100.0
Lead	µg/L	Wk/24hr Comp	< 2.1	42	< 11	780	60	100.0
Suspended Solids	kg/day	Wk/24hr Comp	< 1.5	79	19	150	99	100.0
BOD, C	kg/day	Wk/24hr Comp	0.71	42	6.7	99	66	100.0
Oil & Grease	kg/day	Weekly/Grab	< 3.7	< 26	< 12	50	50	100.0
Cyanide	kg/day	Weekly/Grab	< 0.0037	< 0.026	< 0.012	0.25	0.12	100.0
Copper	kg/day	Wk/24hr Comp	< 0.0052	0.087	< 0.031	0.31	0.077	100.0
Silver	kg/day	Wk/24hr Comp	< 0.0011	0.016	< 0.0052	0.086	0.040	100.0
Lead	kg/day	Wk/24hr Comp	< 0.0022	0.088	< 0.027	2.6	0.20	100.0
						Percent Compliance for Discharges to the Great Miami River		***98.6***
Spillway to Paddy's Run *(Outfall 002)* (d)								
Flow Rate	MGD	Estimate	0.010	0.61	NA	NA	NA	NA
pH	S.U.	Event/Grab	7.9	8.2	NA	Range = 6.5 to 9.0		100.0
Suspended Solids	mg/L	Event/Comp	4	10	NA	100	NA	100.0
Oil & Grease	mg/L	Event/Grab	< 5.0	< 5.0	NA	15	NA	100.0
Chromium (total)	µg/L	Event/Comp	2.4	2.8	NA	4000	NA	100.0
Chromium (+6)	µg/L	Event/Comp	— (e)	— (e)	NA	19	NA	NA
Copper	µg/L	Event/Comp	9.6	13	NA	45	NA	100.0
Nickel	µg/L	Event/Comp	9.3	66	NA	3100	NA	100.0
Silver	µg/L	Event/Comp	< 1.0	< 1.0	NA	12	NA	100.0
						Percent Compliance for Discharge to Paddy's Run		***100.0***

TABLE 11 B: NPDES Data for March – December, 1990

Sampling Location and Parameter	Units	Monitoring Requirements	Daily Monitoring Results Minimum	Maximum	Average (a)	Permit Limits (b) Daily Maximum	Monthly Average	Percent Compliance (c)
Sewage Treatment Plant *(Outfall 601)*								
Flow Rate	MGD	Continuous	0.005	0.32	0.13	NA	NA	NA
pH	S.U.	Continuous	2.7	9.3	NA	Range = 6.5 to 9.0		99.5
Fecal Coliform	#Col/100mL	Wk/24hr Comp	1	1500	19 (f)	2000	1000 (f)	100.0
Suspended Solids	mg/L	Wk/24hr Comp	< 2.0	12	< 3.2	45	30	100.0
BOD, 5	mg/L	Wk/24hr Comp	1.0	17	4.7	45	30	100.0
Fluoride	mg/L	Wk/24hr Comp	0.3	2.0	0.6	4.8	1.7	98.1
Chromium (total)	µg/L	Wk/24hr Comp	1.6	11	< 5.0	29	12	100.0
Copper	µg/L	Wk/24hr Comp	< 4.9	21	13	98	48	100.0
Nickel	µg/L	Wk/24hr Comp	< 2.8	13	< 8.6	44	30	100.0
Suspended Solids	kg/day	Wk/24hr Comp	< 0.20	10	< 1.5	60	40	100.0
BOD, 5	kg/day	Wk/24hr Comp	0.16	11	2.6	60	40	100.0
Fluoride	kg/day	Wk/24hr Comp	0.049	2.2	0.28	6.3	2.2	100.0
Chromium (total)	kg/day	Wk/24hr Comp	0.0002	0.0065	< 0.0022	0.038	0.016	100.0
Copper	kg/day	Wk/24hr Comp	< 0.0007	0.016	< 0.0059	0.13	0.064	100.0
Nickel	kg/day	Wk/24hr Comp	0.0004	0.0098	< 0.0038	0.059	0.040	100.0
						Percent Compliance for Sewage Treatment Plant Discharges		***99.7***
General Sump *(Outfall 602)*								
Flow Rate	MGD	Continuous	0.023	0.32	0.082	NA	NA	NA
pH	S.U.	Weekly/Grab	6.8	8.7	NA	Range = 6.5 to 9.0		100.0
Chromium (total)	µg/L	Wk/24hr Comp	< 1.8	100	< 6.2	54	41	98.1
Chromium (+ 6)	µg/L	Wk/24hr Comp	< 1.0	6.0	< 4.2	17	12	100.0
Copper	µg/L	Wk/24hr Comp	< 4.9	81	< 15	110	66	100.0
Nickel	µg/L	Wk/24hr Comp	< 2.8	46	< 11	170	91	100.0
Chromium (total)	kg/day	Wk/24hr Comp	< 0.0002	0.011	< 0.0017	0.013	0.010	100.0
Chromium (+ 6)	kg/day	Wk/24hr Comp	< 0.0001	0.0036	< 0.0011	0.004	0.003	100.0
Copper	kg/day	Wk/24hr Comp	< 0.0005	0.026	< 0.0041	0.027	0.016	100.0
Nickel	kg/day	Wk/24hr Comp	< 0.0003	0.022	< 0.0028	0.040	0.022	100.0
						Percent Compliance for General Sump Discharges		***99.8***

TABLE 11B: NPDES Data for March – December, 1990

Sampling Location and Parameter	Units	Monitoring Requirements	Daily Monitoring Results Minimum	Maximum	Average (a)	Permit Limits (b) Daily Maximum	Monthly Average	Percent Compliance (c)
Lift Station *(Outfall 604)*								
Flow Rate	MGD	Continuous	0.002	0.41	0.097	NA	NA	NA
pH	S.U.	Continuous	6.8	9.0	NA	Range = 6.5 to 9.0		100.0
Suspended Solids	mg/L	Wk/24hr Comp	< 2.0	31	< 6.2	100	30	100.0
Oil & Grease	mg/L	Weekly/Grab	< 5.0	< 5.0	< 5.0	15	15	100.0
							Percent Compliance for Lift Station Discharges	***100.0***
Bioreacter *(Outfall 605)*								
Flow Rate	MGD	Continuous	0.012	0.17	0.10	NA	NA	NA
pH	S.U.	Continuous	6.6	8.5	NA	NA	NA	NA
Suspended Solids	mg/L	Wk/24hr Comp	< 2.0	88	13	45	30	95.5
BOD, 5	mg/L	Wk/24hr Comp	1.4	75	14	45	30	93.8
Nitrate-Nitrogen	mg/L	Wk/24hr Comp	0.1	14	2.8	150	73	100.0
Fluoride	mg/L	Wk/24hr Comp	2.8	8.3	3.6	4.5	1.3	72.7
Chromium (total)	µg/L	Wk/24hr Comp	2.0	14	5.8	27	12	100.0
Copper	µg/L	Wk/24hr Comp	9.0	30	< 15	90	45	100.0
Nickel	µg/L	Wk/24hr Comp	5.2	43	22	42	29	90.9
Suspended Solids	kg/day	Wk/24hr Comp	< 0.58	12	5.3	38	26	100.0
BOD, 5	kg/day	Wk/24hr Comp	0.68	17	4.6	38	26	100.0
Nitrate-Nitrogen	kg/day	Wk/24hr Comp	0.022	5.9	1.1	120	62	100.0
Fluoride	kg/day	Wk/24hr Comp	0.87	1.9	1.4	3.8	1.1	81.8
Chromium (total)	kg/day	Wk/24hr Comp	0.0012	0.0054	0.0024	0.023	0.010	100.0
Copper	kg/day	Wk/24hr Comp	0.0031	0.0098	< 0.0059	0.077	0.039	100.0
Nickel	kg/day	Wk/24hr Comp	0.0031	0.019	0.0089	0.036	0.025	100.0
							Percent Compliance for Bioreactor Discharges	***97.5***
Retention Basin *(Outfall 606)*								
Flow Rate	MGD	Continuous	0.013	1.00	0.49	NA	NA	NA
pH	S.U.	Continuous	6.6	11	NA	Range = 6.5 to 9.0		98.9
							Percent Compliance for Retention Basin Discharges	***98.9***
							Percent Compliance for all Discharges	***99.1***

TABLE 11 B: NPDES Data for March – December, 1990

Footnotes

(a) Flow-weighted averages. They are shown as less than (<) if more than one quarter of the values were less than the detection limit.

(b) Values have been rounded for clarity of data presentation.

(c) Percent compliance is determined by comparing the noncompliances with the compliance opportunities.

(d) One overflow event – May 17 & 18, 1990. Averages would not represent actual conditions.

(e) Sample collected but not analyzed.

(f) Geometric mean.

TABLE 12: Anions in Surface Water, 1990
Great Miami River

Parameter	Sampling Location [a]	Number of Samples	Concentration (mg/L) Minimum	Maximum	Average	Standards (mg/L)	Percent of Standard [b] Minimum	Maximum	Average
Fluoride									
Upstream of Effluent Line	W1	53	0.3	0.7	0.38	1.8	17	39	21
Downstream of Effluent Line	W3	51	0.2	0.7	0.39	1.8	11	39	22
Downstream of Effluent Line	W4	50	0.2	0.7	0.39	1.8	11	39	22
Nitrate-Nitrogen									
Upstream of Effluent Line	W1	46	1.8	7.6	3.9	10	18	76	39
Downstream of Effluent Line	W3	47	1.6	7.7	3.9	10	16	77	39
Downstream of Effluent Line	W4	45	1.5	7.4	3.9	10	15	74	39
Chloride [c]									
Upstream of Effluent Line	W1	15	16	61	41	250	6.4	24	17
Downstream of Effluent Line	W3	15	16	61	42	250	6.4	24	17
Downstream of Effluent Line	W4	15	15	63	42	250	6.0	25	17

TABLE 12: Anions in Surface Water, 1990
Paddy's Run

Parameter	Sampling Location [a]	Number of Samples	Concentration (mg/L) Minimum	Maximum	Average	Standards (mg/L)	Percent of Standard [b] Minimum	Maximum	Average
Fluoride									
Upstream of FMPC	W5	12	0.2	0.3	0.23	1.8	11	17	13
Onsite	W9	12	0.2	0.3	0.26	1.8	11	17	14
Onsite	W10	12	0.2	1.0	0.35	1.8	11	56	19
Onsite	W11	12	0.2	1.0	0.33	1.8	11	56	18
Downstream of FMPC	W7	13	0.2	2.5	0.48	1.8	11	140	27
Downstream of FMPC	W8	8	0.1	0.3	0.21	1.8	5.6	17	12
Nitrate-Nitrogen									
Upstream of FMPC	W5	12	1.2	5.3	2.8	10	12	53	28
Onsite	W9	12	0.9	5.2	2.5	10	9.0	52	25
Onsite	W10	12	0.7	4.1	2.3	10	7.0	41	23
Onsite	W11	12	1.0	5.7	2.6	10	10	57	26
Downstream of FMPC	W7	11	< 0.1	4.2	2.1	10	< 1.0	42	21
Downstream of FMPC	W8	8	0.2	5.6	1.7	10	2.0	56	17
Chloride [c]									
Upstream of FMPC	W5	4	21	31	25	250	8.4	12	10
Onsite	W9	4	20	28	23	250	8.0	11	9.2
Onsite	W10	4	17	25	21	250	6.8	10	9.4
Onsite	W11	4	20	27	23	250	8.0	11	9.6
Downstream of FMPC	W7	4	18	28	24	250	7.2	11	9.3
Downstream of FMPC	W8	2	20	28	24	250	8.0	11	8.3

(a) See Figure 29 for sampling locations.

(b) Neither the Great Miami River (sampling locations W1, W3, and W4) nor Paddy's Run (sampling locations W5, W7, W8, W9, W10, and W11) are designated as a public water supply (OEPA Regulations, Vol. 1, 3745-1-21). Nevertheless, the FMPC compares the surface water data to public use standards published by OEPA (3745-1-07).

(c) Chloride analyses discontinued on April 11, 1990.

TABLE 13: pH Values for Surface Water, 1990

Great Miami River

Parameter	Sampling Location [a]	Number of Samples	pH Value Minimum	pH Value Maximum	Number of Values Outside Acceptable Range [b]
Upstream of Effluent Line	W1	53	7.7	8.9	0
Downstream of Effluent Line	W3	51	7.7	8.7	0
Downstream of Effluent Line	W4	50	7.7	8.7	0

Paddy's Run

Parameter	Sampling Location [a]	Number of Samples	pH Value Minimum	pH Value Maximum	Number of Values Outside Acceptable Range [b]
Upstream of FMPC	W5	52	7.6	8.4	0
Onsite	W9	51	7.5	8.4	0
Onsite	W10	44	7.6	8.5	0
Onsite	W11	38	7.5	8.5	0
Downstream of FMPC	W7	36	7.5	8.8	0
Downstream of FMPC	W8	27	7.5	8.4	0

(a) See Figure 29 for sampling locations.

(b) Acceptable range, as defined in OEPA Regulation 3745-1-21, is 6.5 – 9.0.

TABLE 14: Uranium in Private Wells, 1990

Well Number [a]	Number of Samples	Concentration (pCi/L) [b] Minimum	Maximum	Average	Percent of Standard [c] Minimum	Maximum	Average
1	11	0.068	0.34	0.14	0.31	1.5	0.64
3	12	0.068	0.34	0.14	0.31	1.5	0.64
4	12	1.1	1.6	1.4	5.0	7.3	6.4
5	12	0.54	1.9	1.2	2.5	8.6	5.5
7	12	0.88	1.2	1.0	4.0	5.5	4.5
8	12	0.41	0.61	0.54	1.9	2.8	2.5
9	12	0.74	0.95	0.88	3.4	4.3	4.0
10	12	0.27	0.61	0.47	1.2	2.8	2.1
11	12	0.74	1.6	1.3	3.4	7.3	5.9
12	9	110	140	130	500 [d]	636 [d]	591 [d]
13	12	0.34	1.1	0.54	1.5	5.0	2.5
14	12	0.88	1.1	1.0	4.0	5.0	4.5
15	12	160	220	190	727 [d]	1,000 [d]	864 [d]
16	12	0.34	0.88	0.47	1.5	4.0	2.1
17	9	26	38	30	118 [d]	173 [d]	136 [d]
18	10	0.20	0.61	0.27	0.91	2.8	1.2
19	11	0.068	0.20	0.14	0.31	0.91	0.64
21	12	0.20	0.41	0.27	0.91	1.9	1.2
22	12	0.47	0.88	0.61	2.1	4.0	2.8
23	12	0.41	1.4	0.61	1.9	6.4	2.8
24	12	0.27	0.47	0.34	1.2	2.1	1.5
25	4 [e]	0.14	0.34	0.27	0.64	1.5	1.2
26	12	0.068	0.20	0.14	0.31	0.91	0.64
27	12	0.14	0.61	0.34	0.64	2.8	1.5
28	4 [e]	0.47	0.54	0.51	2.1	2.5	2.3

TABLE 14: Uranium in Private Wells, 1990

Well Number [a]	Number of Samples	Concentration (pCi/L) [b] Minimum	Maximum	Average	Percent of Standard [c] Minimum	Maximum	Average
29	12	0.88	1.3	1.1	4.0	5.9	5.0
30	5[e]	0.27	0.47	0.34	1.2	2.1	1.5
32	12	0.068	0.14	0.090	0.31	0.64	0.41
33	4[e,g]	0.20	0.41	0.29	0.91	1.9	1.3
34	13	2.0	3.1	2.8	8.9	14	13
35	11	1.1	1.4	1.3	5.0	6.4	5.9
36	2[e,h]	0.68	0.95	0.81	3.1	4.3	3.7
37	1[f,h]		0.81			3.7	
38	2[e,i]	0.068	0.14	0.10	0.31	0.64	0.45

(a) See Figure 36 for well locations. Wells listed in order of entry into the program.

(b) To obtain Bq/L, multiply pCi/L by 0.037.

(c) The FMPC uses 22 pCi/L as the guideline for total uranium in drinking water based on DOE Order 5400.5, February 1990.

(d) These wells are no longer sources of potable water.

(e) Scheduled for quarterly sampling.

(f) Well 37 is scheduled for annual sampling.

(g) Owner of well 33 joined the monitoring program during January 1990.

(h) Owners of wells 36 & 37 joined the monitoring program during July 1990.

(i) Owner of well 38 joined the monitoring program during August 1990.

TABLE 15: Comprehensive Groundwater Samples with Uranium Concentrations Above DOE Guidelines, 1990

Well [a]	Sample Date 1990	Above-Guideline Concentration (pCi/L) [b,c]
1019	March 23	703
1021	March 23	1,878
1022	March 23	8,379
1027	February 15	232
1027	May 2	301
1027	August 2	184
1032	April 18	176
1041	March 26	23
1048	April 16	27
1053	March 30	37
1053	June 26	35
1054	June 25	39
1073	March 22	2,520
1075	March 22	615
1076	March 21	46
1078	March 22	339
1081	February 15	27
1082	February 15	417
1083	February 16	83
1084	March 23	157
1085	June 15	2,831
1087	June 15	23
1089	June 18	50
1111	June 20	25
1112	June 21	597
1113	June 25	1,122
1172	June 25	84
1173	June 25	651
2015	March 8	98
2060	March 15	154
2061	June 19	207
2095	June 19	48
2106	June 15	34
3013	February 12	22
3019	May 1	61
3062	June 19	35
3084	February 21	74

(a) See Figures 40, 41, 42, and 43 for well locations.

(b) To obtain Bq/L, multiply pCi/L by 0.037.

(c) Guideline of 22 pCi/L as listed in DOE Order 5400.5, February 1990.

TABLE 16: Radionuclides in Groundwater, 1990

Well Number [a]	Sample Date 1990	Above-Guideline Concentrations (pCi/L) [b,c]			
		Thorium	Radium	Strontium	Technetium
1039	April 23	—	—	8.6	—
1047	April 16	—	11	—	—
1089	June 18	3.8	—	—	—
1090	June 18	2.5	—	—	—
1110	June 20	3.1	—	—	—
1111	June 20	—	5.1	—	—
1113	June 25	4.0	—	—	—
1173	June 25	4.1	—	—	—
2019	February 9	—	—	—	6,860
2021	February 12	—	—	—	5,080
2021	May 2	—	—	21	—
2067	April 26	—	20	—	—
2097	April 24	—	5	—	—

(a) See Figures 40, 41, and 42 for well locations.

(b) To obtain Bq/L, multiply pCi/L by 0.037.

(c) Guidelines as listed in DOE Order 5400.5, February 1990:

- *Thorium-232: 2 pCi/L*
- *Strontium-90: 8 pCi/L*
- *Radium-226: 5 pCi/L*
- *Radium-228: 5 pCi/L*
- *Technetium-99: 4000 pCi/L*

TABLE 17: Metals in Private Wells, 1990

Metals Listed in Primary Drinking Water Regulations

Well Number [a]	Concentration (mg/L) Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver
1	< 0.010	0.28	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
3	< 0.010	0.39	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
4	< 0.010	< 0.03	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
5	< 0.010	0.040	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
7	< 0.010	0.075	0.009	< 0.006	< 0.006	< 0.010	< 0.003
8	< 0.010	0.064	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
9	< 0.010	0.087	0.007	< 0.006	< 0.006	< 0.010	< 0.003
10	< 0.010	0.067	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
11	< 0.010	0.071	0.007	< 0.006	< 0.006	< 0.010	< 0.003
12 [b]	—	—	—	—	—	—	—
13	< 0.010	0.034	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
14	< 0.010	0.11	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
15	< 0.010	0.068	< 0.006	0.026	0.038	< 0.010	< 0.003
16	< 0.010	0.11	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
17	< 0.010	0.045	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
18	< 0.010	0.074	0.008	< 0.006	< 0.006	< 0.010	< 0.003
19	0.035	< 0.03	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
21	< 0.010	0.076	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
22	< 0.010	0.12	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
23	< 0.010	< 0.03	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
24	< 0.010	0.046	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
25	< 0.010	< 0.03	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
26	< 0.010	0.053	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
27	< 0.010	0.027	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
28	< 0.010	< 0.03	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
29	< 0.010	0.052	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
30	< 0.010	0.044	0.007	< 0.006	< 0.006	< 0.010	< 0.003
32	0.014	< 0.03	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
33	< 0.010	0.069	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
34	< 0.010	< 0.03	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
35	< 0.010	0.031	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
36	< 0.010	0.037	< 0.006	< 0.006	< 0.006	< 0.010	< 0.003
37	< 0.010	0.077	0.008	< 0.006	< 0.006	< 0.010	< 0.003
Primary Standard [c]	0.05	1.0	0.01	0.05	0.05	0.01	0.05

TABLE 17: Metals in Private Wells, 1990

Metals Not Listed in Drinking Water Regulations

Well Number [a]	Concentration (mg/L) Calcium	Magnesium	Nickel	Potassium	Sodium
1	52	18	< 0.009	0.78	14
3	62	20	< 0.009	1.8	27
4	88	43	< 0.009	1.8	31
5	150	51	< 0.009	1.3	24
7	81	23	< 0.009	1.6	6.8
8	79	25	< 0.009	2.5	16
9	67	23	< 0.009	3.0	26
10	110	27	< 0.009	2.2	12
11	83	26	< 0.009	2.8	52
12 [b]	—	—	—	—	—
13	66	19	< 0.009	2.5	15
14	92	27	< 0.009	8.3	20
15	77	20	< 0.009	2.7	13
16	93	25	< 0.009	2.6	40
17	70	18	< 0.009	2.2	11
18	84	23	< 0.009	2.2	9.1
19	49	19	< 0.009	160	20
21	91	24	< 0.009	2.5	11
22	67	19	< 0.009	2.5	11
23	31	9.1	< 0.009	0.88	82
24	98	30	< 0.009	1.9	7.7
25	0.87	0.17	< 0.009	0.17	200
26	79	21	< 0.009	1.5	7.1
27	35	7.8	< 0.009	3.4	6.9
28	28	8.3	< 0.009	0.76	75
29	78	22	< 0.009	2.1	8.7
30	63	18	< 0.009	2.4	11
32	75	27	< 0.009	49	16
33	72	21	< 0.009	1.6	16
34	85	22	< 0.009	2.0	8.5
35	75	22	< 0.009	1.9	20
36	110	21	< 0.009	3.4	12
37	55	21	< 0.009	2.9	10

TABLE 17: Metals in Private Wells, 1990

Metals Listed in Secondary Drinking Water Regulations

Well Number [a]	Concentration (mg/L) Copper	Manganese	Iron	Zinc
1	< 0.014	0.016	2.4	0.74
3	< 0.014	0.014	3.0	0.27
4	0.028	< 0.006	0.099	0.56
5	< 0.014	< 0.006	0.078	0.23
7	< 0.014	0.12	1.3	0.62
8	< 0.014	0.12	0.08	0.56
9	< 0.014	0.21	0.084	0.36
10	< 0.014	0.25	2.9	0.50
11	< 0.014	< 0.006	0.094	0.50
12 [b]	—	—	—	—
13	< 0.014	0.010	0.065	0.37
14	< 0.014	0.11	0.73	0.17
15	0.31	1.8	17	1.4
16	< 0.014	0.29	1.7	0.49
17	< 0.014	0.31	0.74	0.60
18	< 0.014	0.20	2.5	0.65
19	< 0.014	0.24	1.2	0.82
21	< 0.014	0.22	2.0	0.58
22	< 0.014	0.043	0.13	0.41
23	< 0.014	0.025	0.14	0.38
24	< 0.014	0.057	0.084	0.36
25	< 0.014	< 0.006	0.12	0.26
26	< 0.014	0.27	2.8	0.38
27	0.090	< 0.006	0.16	0.48
28	0.014	0.022	0.13	0.39
29	< 0.014	0.17	1.4	0.31
30	0.026	< 0.006	0.10	0.36
32	< 0.014	0.44	1.5	0.59
33	0.048	< 0.006	0.10	0.29
34	< 0.014	0.046	0.63	0.44
35	< 0.014	< 0.006	0.062	0.47
36	< 0.014	< 0.006	0.054	0.85
37	< 0.014	0.023	0.38	0.32
Secondary Standard [c]	1.0	0.05	0.3	5.0

(a) See Figure 37 for well locations. Sample was taken during the month of July.

(b) Sample not taken at well 12 because the pump did not operate during the collection period.

(c) USEPA drinking water regulations (taken from 40 CFR Part 141, National Interim Primary Drinking Water Regualtions – Subpart B – Maximum Contaminant Levels, July, 1984, and from CFR Part 143, National Secondary Drinking Water Regulations – Section 143.3 – Secondary Maximum Contaminant Levels).

TABLE 18: Nitrate in Groundwater, 1990

Well Number [a]	Above-Guideline Concentration (mg/L) [b]
1025	146
1028	247
1031	31
1032	25
1054	17
1081	15
2019	54
2021	24
2022	32
2084	13
2095	11
2643	59
2649	74
3004	22
3019	61
3084	16

(a) See Figures 40, 41, and 42 for well locations.

(b) Guideline of 10 mg/L as listed in 40 CFR Part 141, National Primary Drinking Water Standard.

TABLE 19: Statistically Significant Concentrations of RCRA Constituents in Groundwater, 1990

RCRA Constituent (a)	Units	Well Number (b) 1025	1027	1028	1031	1038	1074	1079	1080	1081	1082	1083
Calcium	mg/L	718	—	—	348	521	145	222	176	319	300	275
Chloride	mg/L	1,040	—	—	1,120	19	160	—	—	37	49	67
Copper	mg/L	—	—	—	0.076	—	—	—	—	—	—	—
1-1 Dichloro-ethane	mg/L	—	—	—	0.045	—	—	—	—	—	—	—
Fluoride	mg/L	—	—	—	1.72	—	1.3	—	—	—	—	—
Iron	mg/L	—	—	—	—	—	—	—	—	—	—	—
Magnesium	mg/L	279	—	—	—	195	78	100	237	111	101	118
Manganese	mg/L	2.57	—	—	—	—	—	—	—	—	—	—
Nickel	mg/L	0.49	—	0.981	0.257	—	0.719	—	—	—	—	—
Nitrate	mg/L	176	—	—	45.7	—	—	—	—	27.5	—	9.41
Sodium	mg/L	258	—	—	533	—	—	—	—	—	—	—
Sulfate	mg/L	677	164	—	267	200	—	244	243	637	510	—
Tetrachloroethane	mg/L	—	—	—	0.3	—	—	—	—	—	—	—
Total Halides	mg/L	—	—	—	0.896	—	—	—	—	—	—	—
Total Carbon	mg/L	—	—	—	15.8	—	—	—	—	—	—	—
Trichloroethene	mg/L	—	—	—	0.53	—	—	—	—	—	—	—
Conductivity	µohlms/L	4,020	—	4,330	3,250	—	1,100	—	—	1,675	1,095	—
pH	standard	8.1	—	6.85	9.85	7.23	—	—	—	—	—	—

TABLE 19: Statistically Significant Concentrations of RCRA Constituents in Groundwater, 1990

RCRA Constituent (a)	Units	Well Number (b)										
		2010	2013	2019	2021	2027	2037	2051	2055	2084	3001	3008
Calcium	mg/L	386	—	266	277	449	228	265	—	397	—	—
Chloride	mg/L	—	—	—	—	140	—	—	—	250	—	—
Copper	mg/L	—	—	—	—	—	—	—	—	—	—	—
1-1 Dichloro-ethane	mg/L	—	—	—	—	—	—	—	—	—	—	—
Fluoride	mg/L	—	—	—	—	—	—	—	—	—	—	—
Iron	mg/L	—	—	—	—	77.8	—	—	—	—	—	—
Magnesium	mg/L	—	—	—	—	72.2	—	—	—	101	—	—
Manganese	mg/L	3.17	—	—	—	1.94	0.814	0.639	—	3.34	0.61	0.663
Nickel	mg/L	—	—	—	—	—	—	—	—	—	—	—
Nitrate	mg/L	—	—	71	53	—	—	—	—	32.4	—	—
Sodium	mg/L	—	—	—	—	—	—	—	—	76.9	—	—
Sulfate	mg/L	739	114	—	293	726	295	799	153	1,090	—	—
Tetrachloroethane	mg/L	—	—	—	—	—	—	—	—	—	—	—
Total Halides	mg/L	—	—	—	—	—	—	—	—	—	—	—
Total Carbon	mg/L	—	—	—	—	—	—	—	—	—	—	—
Trichloroethene	mg/L	—	—	—	—	—	—	—	—	—	—	—
Conductivity	µohlms/L	1,690	—	1,013	1,180	1,925	—	—	—	1,950	—	550
pH	standard	—	—	—	—	—	—	—	—	—	—	—

TABLE 19: Statistically Significant Concentrations of RCRA Constituents in Groundwater, 1990

RCRA Constituent (a)	Units	Well Number (b) 3010	3013	3019	3024	3037	3051	3055	3084	4001	4008	4013
Calcium	mg/L	337	—	404	—	305	—	—	289	—	—	270
Chloride	mg/L	—	—	—	—	—	—	—	—	—	—	—
Copper	mg/L	—	—	—	—	—	—	—	—	—	—	—
1-1 Dichloro-ethane	mg/L	—	—	—	—	—	—	—	—	—	—	—
Fluoride	mg/L	—	—	—	—	—	—	—	—	—	—	—
Iron	mg/L	—	—	—	—	—	—	—	—	—	—	—
Magnesium	mg/L	—	—	—	—	73	—	—	88	—	—	99
Manganese	mg/L	4.32	0.484	3.37	—	0.722	—	—	2.99	0.451	0.571	—
Nickel	mg/L	—	—	—	—	—	—	—	—	—	—	—
Nitrate	mg/L	—	—	60.9	—	—	—	—	16.9	—	—	—
Sodium	mg/L	—	—	—	—	—	—	—	—	—	—	—
Sulfate	mg/L	800	356	650	160	499	186	589	530	—	—	394
Tetrachloroethane	mg/L	—	—	—	—	—	—	—	—	—	—	—
Total Halides	mg/L	—	—	—	—	—	—	—	—	—	—	—
Total Carbon	mg/L	—	—	—	—	—	—	—	—	—	—	—
Trichloroethene	mg/L	—	—	—	—	—	—	—	—	—	—	—
Conductivity	uohlms/L	—	—	—	—	—	—	—	—	—	—	—
pH	standard	—	—	7	—	7	—	7.3	7.38	—	—	—

(a) Data from FMPC 1990 RCRA Annual Report, February 25, 1991.

(b) See Figure 44 for locations..

TABLE 20: Summary of Estimated Radiation Doses, 1990[a]

Type of Dose	Committed Effective Dose[b]	Standard[c]	Percent of Standard
I. Individual	**mrem[d]**	**mrem[d]**	
A. Maximum individual dose from air emissions, excluding radon[e]	0.6	10	6
B. Ingestion[f]			
Produce (141 kg/yr)	0.1	100	0.1
Beef (32 kg/yr)	0.001	100	0.001
Great Miami River Water (2 L/day)	0.02	100	0.02
Great Miami River Fish (4.4 kg/yr)	0.01	100	0.01
Offsite Well Water[g] Well 15 (2 L/day)	32	100	30
C. Direct External[h]	9	100	20
D. Radon Maximum dose to public at FMPC fenceline 8,760 hrs/yr	69	— (i)	
II. 80 km Population Dose[e]	**person-rem**		
Total committed dose equivalent for 2,600,000 people living within 80 km	5	— (i)	
III. Other Background Sources of Dose[j]			
A. Natural Radioactivity	**mrem/yr**		
1. Radon in homes	200		
2. Other natural background radiation: cosmic radiation plus natural terrestrial isotopes, both external and internal.	100		
B. Medical diagnosis[k]	50		
C. Consumer products	10		
D. Atmospheric weapons tests	4.6		

(a) Including dose from all airborne radionuclides listed in Table 21.

(b) The effective dose is the weighted sum of doses delivered to the individual organs of the body. Effective doses are comparable to whole body dose equivalents when considering the effects and risks of low-level radiation doses.

(c) Standards are as included in DOE Order 5400.5, February 1990. Also incorporated are the air emission dose standards of regulation 40 CFR 61, Subpart H (NESHAP).

(d) To obtain mSv multiply mrem by 0.01.

(e) See Table 23 for inhalation dose estimates at all air monitoring stations.

(f) Dose based on environmental measurements according to ICRP 26/30 methodology. ICRP 26/30 based on 50- year committed dose conversion factors.

(g) Well 15 contained the highest average concentration of uranium measured offsite in 1990. Dose calculations based on maximum hypothetical dose from drinking this water. This well is no longer a source of drinking water.

(h) Whole body dose calculated from measured exposure rate at nearest residence west of the K-65 Silos, using environmental thermoluminescent dosimeters.

(i) There are no applicable standards.

(j) From NCRP-93, "Ionizing Radiation Exposure of the Population of the United States."

(k) Medical dose estimates are population averages and will not necessarily be applicable to each individual.

TABLE 21: Estimated Airborne Emissions for FMPC, 1990

Radionuclide	Total Curies	Measured Curies [a]	Estimated Curies [b]	
			Waste Pits [c]	Remaining Sources [d]
Uranium – 234	0.000819	0.000000793	0.000285	0.000533
Uranium – 235	0.0000354	0.000000042	0.00000717	0.0000282
Uranium – 236	0.0000241	0.0000000308	0.00000331	0.0000207
Uranium – 238	0.00108	0.000000886	0.000487	0.000596
Strontium – 90	0.00000342	0.0000000047	0.000000272	0.00000314
Technetium – 99	0.000105	0.0000000981	0.0000386	0.0000660
Ruthenium – 106	0.0000123	0.0000000182	0.00	0.0000123
Cesium – 137	0.0000104	0.0000000136	0.00000119	0.00000916
Barium – 137m	0.0000104	0.0000000136	0.00000119	0.00000916
Radium – 226	0.0000156	0.0000000006	0.0000152	0.000000379
Radium – 228	0.00000341	0.0000000023	0.00000189	0.00000151
Thorium – 228	0.0000185	0.0000000238	0.00000244	0.0000160
Thorium – 230	0.000320	0.0000000701	0.000273	0.0000472
Thorium – 232	0.00000441	0.0000000037	0.00000189	0.00000252
Thorium – 234	0.00285	0.0000035	0.000486	0.00236
Protactinium – 234m	0.00285	0.00000350	0.000486	0.00236
Neptunium – 237	0.000000542	0.0000000003	0.000000350	0.000000191
Plutonium – 238	0.000000303	0.0000000003	0.0000000762	0.000000223
Plutonium – 239	0.00000165	0.0000000022	0.000000188	0.00000146
Plutonium – 240	0.000000553	0.0000000005	0.000000188	0.000000364
Plutonium –241	0.00000652	0.0000000078	0.00000129	0.00000523
Plutonium – 242	0.000000000152	0.000000000000124	0.0000000000680	0.0000000000843

(a) Measured emissions include two monitored stacks (dust collectors) that operated during 1990. They are measured by single-point continuous isokinetic samplers.

(b) There were no nonroutine releases during 1990.

(c) Fugitive emissions from the waste pits.

(d) Includes three unmonitored stacks, two building vents, laboratory emissions, and the cooling tower.

TABLE 22: Estimated Population Distribution within 80 km (50 miles) of the FMPC[a]

Compass Sector	0 – 1.6 km (0 – 1 mi)	1.6 – 3.2 km (1 – 2 mi)	3.2 – 4.8 km (2 – 3 mi)	4.8 – 6.4 km (3 – 4 mi)	6.4 – 8 km (4 – 5 mi)	8 – 16 km (5 – 10 mi)	16 – 32 km (10 – 20 mi)	32 – 48 km (20 – 30 mi)	48 – 64 km (30 – 40 mi)	64 – 80 km (40 – 50 mi)
N	7	64	77	108	125	1,008	16,676	7,161	16,737	12,369
NNE	5	57	65	111	300	13,702	7,595	8,288	31,333	78,291
NE	8	206	120	129	317	38,550	45,545	96,440	189,514	317,133
ENE	16	106	2,714	5	47	31,258	17,295	31,720	13,520	25,702
E	24	62	119	89	235	34,442	53,951	39,591	17,675	10,403
ESE	16	68	137	206	292	38,965	160,794	72,536	24,073	13,277
SE	8	69	107	153	192	52,064	273,363	94,394	26,815	15,853
SSE	15	67	88	256	591	20,714	218,659	55,517	9,311	8,685
S	8	69	97	384	620	8,376	32,804	34,309	9,475	9,575
SSW	9	77	154	290	354	4,814	9,492	7,718	6,022	9,695
SW	9	85	143	129	130	1,171	15,147	10,752	3,708	4,916
WSW	17	84	142	216	296	7,081	3,749	7,092	7,243	5,908
W	9	79	135	215	270	2,488	3,650	10,355	5,805	16,385
WNW	8	66	102	161	213	1,596	4,242	6,469	4,255	12,060
NW	12	63	99	154	219	1,091	1,398	3,222	26,366	9,417
NNW	17	64	102	186	316	1,538	12,963	4,921	48,181	13,725
Total	188	1,286	4,401	2,792	4,517	258,858	877,323	490,485	440,033	563,394

Total for all sectors: 2,643,277

(a) Based on an extrapolation from 1980 census data by Geographic Data Systems Section, Computing and Telecommunications Division at Oak Ridge National Laboratory, May 1989.

TABLE 23: Estimated Committed Effective Doses at Air Monitoring Stations, 1990

AMS[a]	50 Year Dose Commitment, mrem [b] 1989	1990	Percent of Standard [c]
1	0.33	0.2	0.2
2	0.40	0.2	0.2
3	0.68	0.3	0.3
4	0.27	0.1	0.1
5	0.24	0.1	0.1
6	0.40	0.2	0.2
7	0.27	0.2	0.2
8	0.61	0.7	—[d]
9	1.6	1.0	—[d]

(a) Doses at offsite Air Monitoring Stations were not calculated because of delays in receiving data from the contract laboratory.

(b) The effective dose is the weighted sum of doses delivered to the individual organs of the body. Values reported in this table are based on concentrations of radionuclides measured in the air sampled by the various air monitoring stations. These values are very conservative since "less than detectable" concentrations (from Table 2) were included and background radionuclide concentrations were not subtracted.

(c) Standard is 100 mrem for all pathways, as noted in DOE Order 5400.5, February 1990.

(d) Onsite AMS; standards for dose to public not applicable.

TABLE 24: Direct Radiation Dose, 1990

Sampling Location[a]	Dose Rate (μrem/hr) Minimum	Maximum	Average[b]
Fenceline			
AMS 1	6.7	7.9	7.3
AMS 2	7.3	7.9	7.6
AMS 3	6.6	7.6	7.2
AMS 4	6.6	7.8	7.3
AMS 5	6.7	7.3	7.1
AMS 6	12	13	13
AMS 7	6.6	7.5	7.1
Onsite			
AMS 8	6.1	7.4	6.9
AMS 9	9.0	10	9.4
Offsite			
AMS 10	4.9	6.0	5.4
AMS 11	6.6	7.6	7.1
AMS 12	6.2	6.9	6.8
AMS 13	5.9	6.7	6.3
BKGD[c]	5.6	7.5	6.3

(a) See Figure 15 for locations.

(b) Average dose rate is calculated from four quarterly measurements.

(c) Background is average of measurements at four locations between 10 and 40 km from the FMPC.

TABLE 25: DOE Quality Assessment Program for Environmental Radionuclide Analyses FMPC Laboratories Performance Results, 1990

Sample Type	Sample Number	Units	Uranium Values FMPC Laboratories	EML[a]	Ratio FMPC Value/EML Value
Water	90 – 03	µg/L	80.0 ± 6.3	78.8 ± 1.6	1.02 ± 0.08 [b]
Water	90 – 09	µg/L	21.1 ± 1.7	18.9 ± 0.6	1.12 ± 0.10
Air Filter	90 – 03	µg/Filter	2.42 ± 0.25	2.01 ± 0.12	1.20 ± 0.15
	90 – 03	µg/Filter	3.05 ± 0.10	2.01 ± 0.12	1.52 ± 0.12
Air Filter	90 – 09	µg/Filter	1.15 ± 0.17	0.985 ± 0.000	1.17 ± 0.18
	90 – 09	µg/Filter	1.21 ± 0.07	0.985 ± 0.000	1.23 ± 0.08
Soil	90 – 03	µg/g	10.3 ± 3.2	10.3 ± 0.31	1.00 ± 0.31
Soil	90 – 09	µg/g	1.74 ± 0.40	2.19 ± 0.07	0.79 ± 0.19

(a) DOE's Environmental Measurements Laboratory.

(b) The plus/minus (±) uncertainty for the ratios is equal to: $(F^2 + E^2)^{1/2}/EV$ where F is the plus/minus (±) uncertainty in the FMPC value, E is the plus/minus (±) uncertainty in the EML value, and EV is the EML uranium value.

TABLE 26: USEPA Quality Assurance Program for Waste Water Analyses FMPC Laboratories Performance Evaluation, 1990[a]

Parameter	Units	Values FMPC Laboratories	Values True [b]	USEPA Acceptance Limits [c]	USEPA Performance Evaluation [d]
Ammonia – Nitrogen	mg/L	3.67	3.60	2.80 – 4.34	Acceptable
Biochemical Oxygen Demand	mg/L	42	50.9	29.1 – 72.8	Acceptable
Nitrate – Nitrogen (Brucine Sulfate Method)	mg/L	2.30	2.20	1.73 – 2.67	Acceptable
Oil & Grease	mg/L	16.5	18.0	10.6 – 23.2	Acceptable
Residual Chlorine	mg/L	1.29	1.50	0.896 – 1.82	Acceptable
Total Suspended Solids	mg/L	67.9	73.0	61.3 – 78.0	Acceptable
pH	Standard	6.03	6.00	5.86 – 6.09	Acceptable
Chromium (Total)	µg/L	50	50.0	37.2 – 61.0	Acceptable
Copper	µg/L	82	85.0	72.9 – 94.5	Acceptable
Iron	µg/L	780	650	559 – 737	Not Acceptable
Lead	µg/L	93.0	100	76.0 – 121	Acceptable
Nickel	µg/L	215	200	172 – 227	Acceptable

(a) USEPA Discharge Monitoring Report (DMR) Quality Assurance (QA) Program. The FMPC, along with all other National Pollutant Discharge Elimination System (NPDES) permit holders, is required to participate in these annual laboratory performance evaluation studies (Section 308(a) of the Clean Water Act).

(b) Actual parameter concentrations established by USEPA based on theoretical calculations or a reference value when necessary.

(c) Laboratory measured values which fall within this range are considered acceptable by the USEPA.

(d) USEPA DMR-QA Study Number 010 conducted during 1990.

TABLE 27: Proficiency Environmental Testing Quality Assurance Program for Water Analyses, 1990

Summary of Performance of FMPC Laboratories

Parameter	Units	Number of Analyses	Range of True Values	Percent Recovery [a] Minimum	Maximum	Average	Standard Deviations from Mean [b] Minimum	Maximum	Average	Percentage Acceptable [c]
Ammonia – Nitrogen	mg/L	11	0.26 – 2.46	49	124	96	0.01	2.20	0.70	100
Biochemical Oxygen Demand	mg/L	14	13.8 – 221	79	160	120	0.07	2.91	1.26	86
Calcium	mg/L	16	4.87 – 42.7	88	248	109	0.04	21.9	1.79	94
Chloride	mg/L	12	47.2 – 105	91	103	98	0.05	1.83	0.64	100
Fluoride	mg/L	12	1.20 – 7.12	92	108	100	0.11	1.55	0.66	100
Magnesium	mg/L	14	3.18 – 11.0	89	110	97	0.02	1.73	0.92	100
Nitrate – Nitrogen	mg/L	16	0.20 – 1.80	90	108	103	0.02	1.08	0.45	100
Oil & Grease	mg/L	15	5.32 – 47.9	15	116	66	0.02	2.88	1.19	87
Potassium	mg/L	14	5.44 – 18.3	94	115	105	0.09	1.48	0.75	100
Residual Chlorine	mg/L	15	0.13 – 4.30	89	200	107	0.00	6.35	0.91	93
Sodium	mg/L	14	28.6 – 85.1	95	106	102	0.03	0.83	0.45	100
Sulfate	mg/L	12	10.3 – 50.1	86	118	104	0.06	1.66	0.71	100
Total Suspended Solids	mg/L	12	48.2 – 311	94	282	115	0.03	26.9	3.13	92
pH	Standard Units	12	3.54 – 7.84	102	113	107	0.10	1.34	0.58	100
Arsenic	µg/L	10	33.7 – 414	96	114	106	0.06	0.73	0.47	100
Barium	µg/L	12	333 – 2,235	94	111	102	0.02	1.17	0.51	100
Cadimum	µg/L	10	14.7 – 214	100	129	109	0.18	2.56	0.71	100
Chromium (Total)	µg/L	14	21.8 – 250	91	118	106	0.00	1.78	0.64	100

TABLE 27: Proficiency Environmental Testing Quality Assurance Program for Water Analyses, 1990

Summary of Performance of FMPC Laboratories

Parameter	Units	Number of Analyses	Range of True Values	Percent Recovery [a] Minimum	Maximum	Average	Standard Deviations from Mean [b] Minimum	Maximum	Average	Percentage Acceptable [c]
Chromium (Hexavalent)	µg/L	14	0.02 – 0.44	57	160	97	0.02	11.1	1.68	93
Copper	µg/L	14	28.4 – 269	91	134	107	0.13	4.62	1.11	86
Iron	µg/L	12	34.9 – 523	82	135	100	0.01	1.96	0.84	100
Lead	µg/L	14	24.5 – 402	99	131	108	0.08	1.68	0.76	100
Manganese	µg/L	12	30.2 – 454	90	106	99	0.01	1.32	0.49	100
Nickel	µg/L	14	25.6 – 240	100	131	110	0.08	2.80	0.90	93
Selenium	µg/L	7	14.7 – 175	93	110	101	0.11	0.58	0.35	100
Silver	µg/L	14	17.2 – 243	95	128	110	0.13	2.08	0.92	100
Uranium	µg/L	16	40.0 – 1401	90	135	109	0.18	1.65	0.87	100
Zinc	µg/L	12	24.3 – 225	98	124	107	0.04	2.36	0.61	100
									Percentage acceptable for all measurements	***97***

(a) Percent recovery is the FMPC measured value divided by the true parameter concentration multiplied by 100.

(b) The standard deviation indicates the closeness of the FMPC measurement result to the mean value reported by Analytical Products Group, Inc., which conducts the testing program. The standard deviation would be 0.00 if the FMPC result and mean value were exactly the same. The mean value is calculated from the results obtained by all laboratories participating in the control program. Any measurement results which are significantly different from the true parameter concentration or statistically different from the majority of results obtained by the other laboratories are not included in evaluating the mean value.

(c) This is the percentage of FMPC measurement results for each parameter which met the USEPA "Acceptable" criteria of being within 2.58 standard deviations of the mean value.

TABLE 28: FMPC – ODH Uranium Sampling Comparison, 1989

Surface Water Sampling Locations

Sampling Location [a]	Sampling Date	Concentration (pCi/L) FMPC			Concentration (pCi/L) [b] ODH			Equivalent Results
W1	January 17, 1989	1.1	±	0.40	1.2	±	0.51	YES
	February 28, 1989	1.1	±	0.40	1.3	±	0.53	YES
	March 28, 1989	1.1	±	0.40	1.1	±	0.51	YES
	April 25, 1989	1.4	±	0.49	1.8	±	0.66	YES
	May 23, 1989	1.4	±	0.49	1.8	±	0.62	YES
	June 21, 1989	1.5	±	0.52	1.6	±	0.41	YES
	July 25, 1989	1.2	±	0.42	0.79	±	0.33	YES
	August 22, 1989	1.3	±	0.45	1.0	±	0.37	YES
	September 26, 1989	1.3	±	0.45	0.73	±	0.27	YES
	October 26, 1989	1.8	±	0.61	1.0	±	0.50	YES
	November 21, 1989	1.6	±	0.56	1.8	±	0.58	YES
W3	January 17, 1989	1.4	±	0.49	1.5	±	0.6	YES
	February 28, 1989	1.2	±	0.42	1.1	±	0.48	YES
	March 28, 1989	1.5	±	0.52	1.2	±	0.53	YES
	April 25, 1989	1.6	±	0.56	1.2	±	0.55	YES
	May 23, 1989	1.4	±	0.47	1.1	±	0.49	YES
	June 21, 1989	1.6	±	0.56	1.3	±	0.38	YES
	July 25, 1989	1.3	±	0.45	1.4	±	0.03	YES
	August 22, 1989	1.4	±	0.47	1.2	±	0.39	YES
	September 26, 1989	1.5	±	0.52	1.6	±	0.40	YES
	October 26, 1989	2.4	±	0.84	3.3	±	0.86	YES
	November 21, 1989	1.7	±	0.59	1.8	±	0.65	YES

TABLE 28: FMPC – ODH Uranium Sampling Comparison, 1989

Sampling Location [a]	Sampling Date	Concentration (pCi/L) [b] FMPC			ODH			Equivalent Results
W4	February 28, 1989	1.2	±	0.42	1.5	±	0.57	YES
	March 28, 1989	1.3	±	0.45	0.73	±	0.44	YES
	April 25, 1989	1.4	±	0.49	1.5	±	0.58	YES
	May 23, 1989	1.8	±	0.61	2.8	±	0.77	YES
	June 21, 1989	1.6	±	0.56	2.1	±	0.47	YES
	July 25, 1989	1.4	±	0.49	1.1	±	0.023	YES
	August 22, 1989	1.4	±	0.49	2.2	±	0.51	YES
W5	October 26, 1989	1.7	±	0.59	1.4	±	0.6	YES
W7	January 17, 1989	1.8	±	3.8	4.2	±	0.95	NO
	March 28, 1989	6.4	±	2.2	6.9	±	1.2	YES
	April 25, 1989	5.7	±	2.0	4.8	±	1.0	YES
	May 23, 1989	2.7	±	0.94	2.9	±	0.78	YES
	June 21, 1989	9.5	±	3.3	12	±	1.1	YES
	July 25, 1989	4.3	±	1.5	2.6	±	0.54	YES
W8	August 22, 1989	2.8	±	0.99	1.7	±	0.45	YES
	September 26, 1989	1.6	±	0.56	1.5	±	0.38	YES
	October 26, 1989	1.9	±	0.66	2.0	±	0.70	YES
	November 21, 1989	3.5	±	1.2	3.0	±	0.60	YES
W9	January 17, 1989	1.8	±	0.61	1.0	±	0.49	YES
	March 28, 1989	1.1	±	0.38	1.9	±	0.66	YES
	April 25, 1989	1.1	±	0.40	1.3	±	0.57	YES
	May 23, 1989	0.68	±	0.23	1.4	±	0.54	YES
	June 21, 1989	1.2	±	0.42	1.3	±	0.38	YES
	July 25, 1989	0.81	±	0.28	1.0	±	0.022	YES
	August 22, 1989	0.61	±	0.21	0.26	±	0.25	YES
	September 26, 1989	1.6	±	0.56	1.5	±	0.38	YES
	November 21, 1989	1.8	±	0.63	1.9	±	0.70	YES

TABLE 28: FMPC – ODH Uranium Sampling Comparison, 1989

Private Well Locations

Sampling Location [a]	Sampling Date	Concentration (pCi/L) [b] FMPC			ODH			Equivalent Results
Well 4	January 17, 1989	1.6	±	0.56	2.2	±	0.6	YES
	February 28, 1989	1.6	±	0.56	2.2	±	0.67	YES
	March 28, 1989	1.4	±	0.47	0.84	±	0.46	YES
	April 25, 1989	1.1	±	0.4	1.6	±	0.62	YES
	May 23, 1989	1.6	±	0.56	3.0	±	0.8	YES
	June 21, 1989	1.7	±	0.59	2.4	±	0.51	YES
	July 25, 1989	1.4	±	0.47	2.1	±	0.044	NO
	August 22, 1989	1.1	±	0.38	1.5	±	0.43	YES
	September 26, 1989	1.2	±	0.42	2.6	±	0.51	YES
	October 26, 1989	1.5	±	0.52	1.6	±	0.63	YES
	November 21, 1989	1.5	±	0.52	1.0	±	0.7	YES
Well 5	June 21, 1989	1.6	±	0.56	2.1	±	0.47	YES
Well 7	September 26, 1989	1	±	0.35	1.5	±	0.63	YES
Well 12	January 17, 1989	160	±	54	180	±	6.1	YES
Well 13	February 28, 1989	0.34	±	0.12	0.47	±	0.34	YES
	July 25, 1989	0.41	±	0.14	0.50	±	0.012	YES

TABLE 28: FMPC – ODH Uranium Sampling Comparison, 1989

Sampling Location [a]	Sampling Date	Concentration (pCi/L) [b] FMPC			Concentration (pCi/L) [b] ODH			Equivalent Results
Well 14	January 17, 1989	0.81	±	0.28	0.68	±	0.40	YES
	February 28, 1989	0.68	±	0.23	1.0	±	0.47	YES
	March 28, 1989	0.81	±	0.28	0.79	±	0.42	YES
	April 25, 1989	0.88	±	0.30	0.53	±	0.74	YES
	May 23, 1989	0.74	±	0.26	0.94	±	0.46	YES
	June 21, 1989	0.74	±	0.26	0.94	±	0.33	YES
	July 25, 1989	0.95	±	0.33	0.55	±	0.013	NO
	August 22, 1989	0.81	±	0.28	0.84	±	0.35	YES
	September 26, 1989	0.95	±	0.33	1.5	±	0.63	YES
	October 26, 1989	1.1	±	0.40	0.40	±	0.40	YES
	November 21, 1989	0.95	±	0.33	1.0	±	0.10	YES
Well 15	January 17, 1989	200	±	68	210	±	6.5	YES
	February 28, 1989	180	±	63	230	±	6.8	YES
	March 28, 1989	170	±	59	180	±	5.9	YES
	April 25, 1989	180	±	61	240	±	7.0	YES
	May 23, 1989	160	±	56	210	±	6.5	YES
	June 21, 1989	160	±	54	200	±	2.1	YES
	July 25, 1989	210	±	73	190	±	4.4	YES
	August 22, 1989	190	±	66	180	±	4.2	YES
	September 26, 1989	200	±	70	210	±	4.6	YES
	October 26, 1989	210	±	73	220	±	6.7	YES
	November 21, 1989	180	±	61	200	±	1.3	YES

TABLE 28: FMPC – ODH Uranium Sampling Comparison, 1989

Sampling Location [a]	Sampling Date	Concentration (pCi/L) FMPC	Concentration (pCi/L) [b] ODH	Equivalent Results
Well 19	January 17, 1989	0.14 ± 0.047	0.63 ± 0.44	YES
	February 28, 1989	0.14 ± 0.047	0.37 ± 0.31	YES
	March 28, 1989	0.068 ± 0.023	0.053 ± 0.18	YES
	April 25, 1989	0.14 ± 0.047	< 1.0	YES
	May 23, 1989	0.068 ± 0.023	0.58 ± 0.37	NO
	June 21, 1989	0.14 ± 0.047	0.1 ± 0.16	YES
	July 25, 1989	0.14 ± 0.047	0.10 ± 0.0041	YES
	August 22, 1989	0.14 ± 0.047	< 1.0	YES
	September 26, 1989	0.14 ± 0.047	0.47 ± 0.22	NO
	October 26, 1989	0.14 ± 0.047	0.16 ± 0.34	YES
	November 21, 1989	0.068 ± 0.023	3.0 ± 1.0	NO
Well 21	April 25, 1989	0.27 ± 0.094	0.47 ± 0.34	YES
Well 22	March 28, 1989	0.68 ± 0.23	0.89 ± 0.47	YES
Well 23	May 23, 1989	0.54 ± 0.19	1.0 ± 0.47	YES
Well 26	January 17, 1989	0.20 ± 0.070	0.47 ± 0.34	YES
Well 29	November 21, 1989	1.2 ± 0.42	1.0 ± 0.70	YES
Well 30	August 22, 1989	0.34 ± 0.12	0.31 ± 0.26	YES
Well 34	October 26, 1989	0.74 ± 0.26	0.70 ± 0.40	YES
Well 35	October 26, 1989	1.1 ± 0.38	1.2 ± 0.56	YES
			Percentage equivalent for all measurements	***94.3***

(a) See Figures 29 and 36 for locations.

(b) To obtain Bq/L, multiply pCi/L by 0.037.

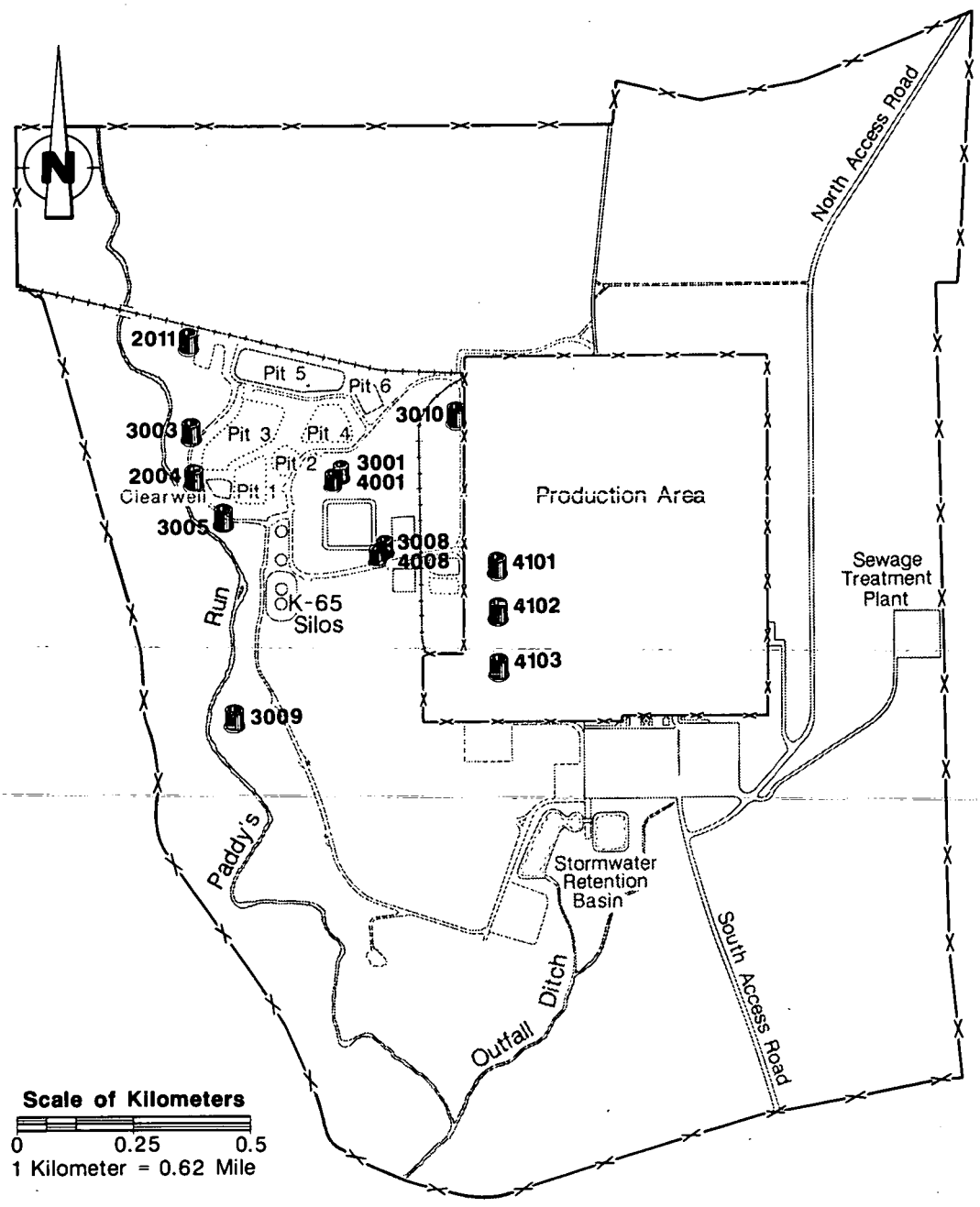
APPENDIX B

Final Summary of Traditional Onsite Well Sampling Results

Until 1990 when the Comprehensive Groundwater Monitoring Program assumed responsibility for providing groundwater information from over 200 wells, 13 onsite wells were the focus of Environmental Monitoring's groundwater research. In 1990, these wells were incorporated into the comprehensive sampling schedule and will therefore no longer be analyzed as a separate group of wells. This appendix provides a final summary of these wells' sampling results.

Figure 61 shows the location of the wells, including the original production wells (4101, 4102, and 4103), drilled in 1951. Tables 29 through 33 give the 1990 sampling results of these wells for uranium, nitrate-nitrogen, sulfate, and chloride concentrations, and for pH values. Finally, Figures 62 through 74 illustrate uranium concentrations measured in these traditional onsite wells during recent years.

FIGURE 61: Traditional Onsite Monitoring Wells



LEGEND

- Single Well
- Cluster Well
- Plant Perimeter
- Production Area Perimeter

1302

TABLE 29: Uranium in Traditional Onsite Wells, 1990

Well [a]	Number of Samples	Concentration (pCi/L) [b] Minimum	Maximum	Average	Percent of Standard [c] Minimum	Maximum	Average
2004	11	2.4	9.5	5.0	11	43	23
2011	3	0.14	0.27	0.23	0.61	1.2	1.0
3001	10	0.14	8.8	5.9	0.61	49	27
3003	10	1.5	6.8	2.8	6.8	31	13
3005	10	1.1	3.0	1.8	4.9	14	8.2
3008	11	0.20	1.8	0.69	0.92	8.0	3.1
3009	11	0.47	5.7	2.3	2.1	26	10
3010	11	0.41	5.1	2.1	1.8	23	9.4
4001	10	0.068	0.61	0.21	0.31	2.8	0.95
4008	11	0.068	7.4	0.87	0.31	34	4.0
4101	11	0.068	0.27	0.13	0.31	1.2	0.59
4102	11	0.068	0.20	0.11	0.31	0.92	0.50
4103	11	0.068	0.14	0.10	0.31	0.61	0.45

(a) See Figure 61 for well locations.
(b) To obtain Bq/L, multiply pCi/L by 0.037.
(c) For wells 4101, 4102, and 4103, the FMPC uses 22 pCi/L as the guideline for total uranium in drinking water based on DOE Order 5400.5, February 1990. For wells 2004 through 4008, the percent of standard has been calculated for reference purposes only. These wells do not supply potable water, but are used for monitoring groundwater quality only.

TABLE 30: Nitrate-Nitrogen in Traditional Onsite Wells, 1990

Well Number [a]	Number of Samples	Concentration (mg/L) Minimum	Maximum	Percent of Standard [b] Minimum	Maximum
2004	4	< 0.1	1.7	< 1.0	17.0
2011	1		< 0.1		< 1.0
3001	3	< 0.1	0.2	< 1.0	2.0
3003	3	< 0.1	0.2	< 1.0	2.0
3005	4	< 0.1	0.1	< 1.0	1.0
3008	4	< 0.1	0.1	< 1.0	1.0
3009	4	< 0.1	< 0.1	< 1.0	< 1.0
3010	4	< 0.1	< 0.1	< 1.0	< 1.0
4001	3	< 0.1	0.2	< 1.0	2.0
4008	4	< 0.1	< 0.1	< 1.0	< 1.0
4101	4	< 0.1	0.2	< 1.0	2.0
4102	4	< 0.1	0.1	< 1.0	1.0
4103	4	< 0.1	0.2	< 1.0	2.0

(a) See Figure 61 for well locations.

(b) For wells 4101, 4102, and 4103, the FMPC uses the USEPA standard of 10 mg/L for nitrate-nitrogen concentration in drinking water as specified in 40 CFR Part 141, National Primary Drinking Water Standard. For wells 2004 through 4008, the percent of standard has been calculated for reference purposes only. These wells do not supply potable water, but are used for monitoring groundwater quality only.

TABLE 31: Sulfate in Traditional Onsite Wells, 1990

Well [a]	Number of Samples	Concentration (mg/L) Minimum	Maximum	Percent of Standard [b] Minimum	Maximum
2004	3	56	64	22	26
2011	1		105		42
3001	2	41	42	16	17
3003	3	65	67	26	27
3005	3	64	76	26	30
3008	3	11	68	4.4	27
3009	3	26	49	10	20
3010	3	288	361	115	144
4001	2	< 10	17	< 4.0	6.8
4008	3	< 10	< 10	< 4.0	< 4.0
4101	3	114	122	46	49
4102	3	13	17	5.2	6.8
4103	3	33	43	13.2	17.2

(a) See Figure 61 for well locations.

(b) For wells 4101, 4102, and 4103, the FMPC uses the USEPA standard of 250 mg/L for sulfate concentration in drinking water as specified in 40 CFR Part 143, National Secondary Drinking Water Standard. For wells 2004 through 4008, the percent of standard has been calculated for reference purposes only. These wells do not supply potable water, but are used for monitoring groundwater quality only.

TABLE 32: Chloride in Traditional Onsite Wells, 1990

Well Number [a]	Number of Samples	Concentration (mg/L) Minimum	Concentration (mg/L) Maximum	Percent of Standard [b] Minimum	Percent of Standard [b] Maximum
2004	3	18	26	7.2	10
2011	1		24		9.6
3001	2	14	20	5.6	8.0
3003	3	20	25	8.0	10
3005	3	20	22	8.0	8.8
3008	3	12	20	4.8	8.0
3009	3	21	22	8.4	8.8
3010	3	55	59	22	24
4001	2	24	26	9.6	10
4008	3	< 10	11	< 4.0	4.4
4101	3	36	39	14	16
4102	3	25	29	10	12
4103	3	11	12	4.4	4.8

(a) See Figure 61 for well locations.

(b) For wells 4101, 4102, and 4103, the FMPC uses the USEPA standard of 250 mg/L for chloride concentration in drinking water as specified in 40 CFR Part 143, National Secondary Drinking Water Standard. For wells 2004 through 4008, the percent of standard has been calculated for reference purposes only. These wells do not supply potable water, but are used for monitoring groundwater quality only.

TABLE 33: pH Values for Traditional Onsite Wells, 1990

Well Number [a]	Number of Samples	pH Value Minimum	pH Value Maximum	Number of Values Outside Acceptable Range [b]
2004	4	7.5	8.0	0
2011	1		7.6	0
3001	3	7.4	7.7	0
3003	3	7.8	8.0	0
3005	4	7.3	8.0	0
3008	4	7.7	8.8	0
3009	4	7.7	8.1	0
3010	4	6.9	7.5	0
4001	3	7.3	7.8	0
4008	4	7.5	8.1	0
4101	4	7.1	7.6	0
4102	4	7.4	7.8	0
4103	4	7.4	7.8	0

(a) See Figure 61 for well locations.

(b) For wells 4101, 4102, and 4103, the FMPC uses the USEPA range of 6.5 to 8.5 for pH of drinking water as specified in 40 CFR Part 143, National Secondary Drinking Water Standard. For wells 2004 through 4008, the acceptable range is provided for reference purposes only. These wells do not supply potable water, but are used for monitoring groundwater quality only.

FIGURE 62: Uranium Concentration in Well 2004, 1980 to 1990

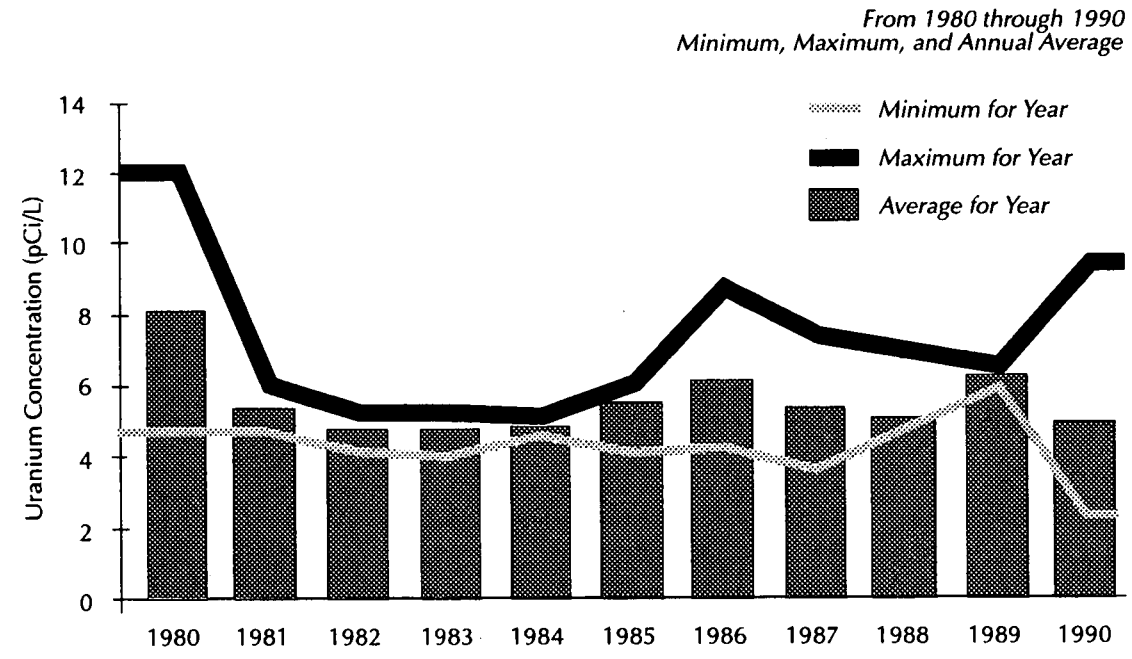


FIGURE 63: Uranium Concentration in Well 2011, 1982 to 1990

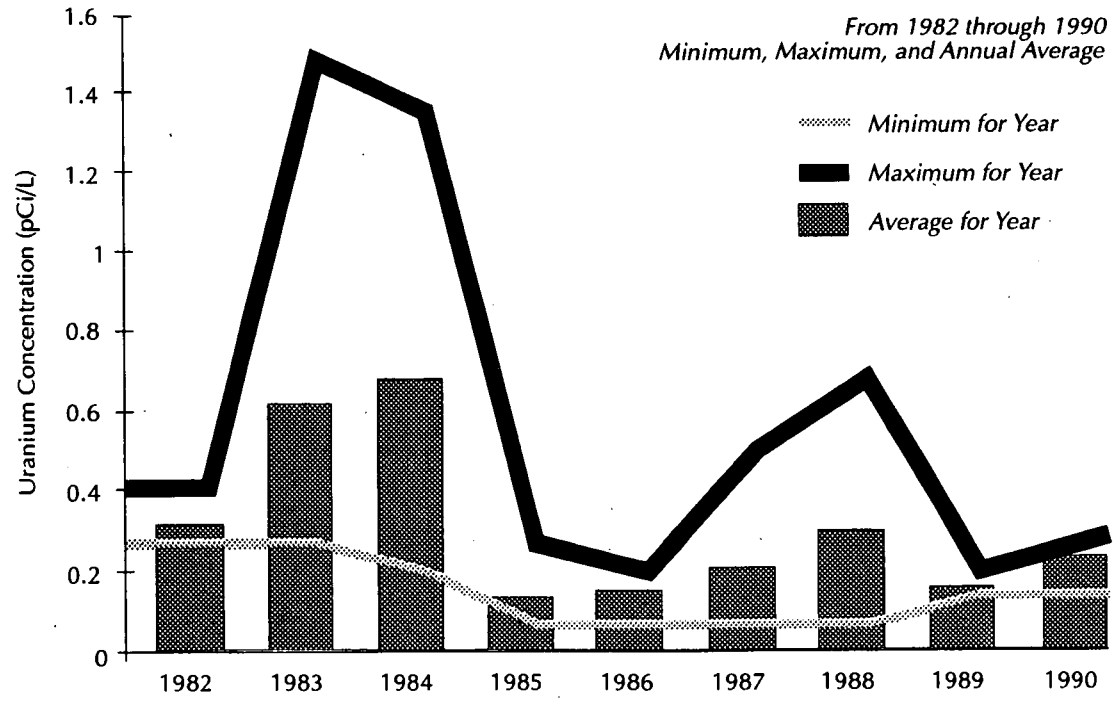


FIGURE 64: Uranium Concentration in Well 3001, 1980 to 1990

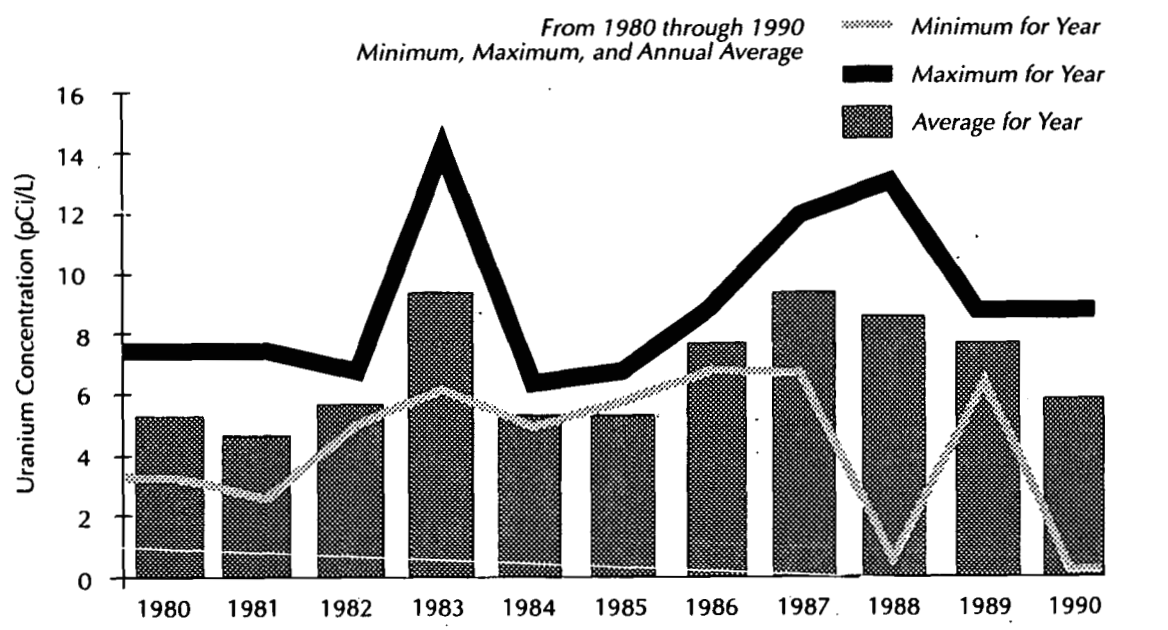


FIGURE 65: Uranium Concentration in Well 3003, 1980 to 1990

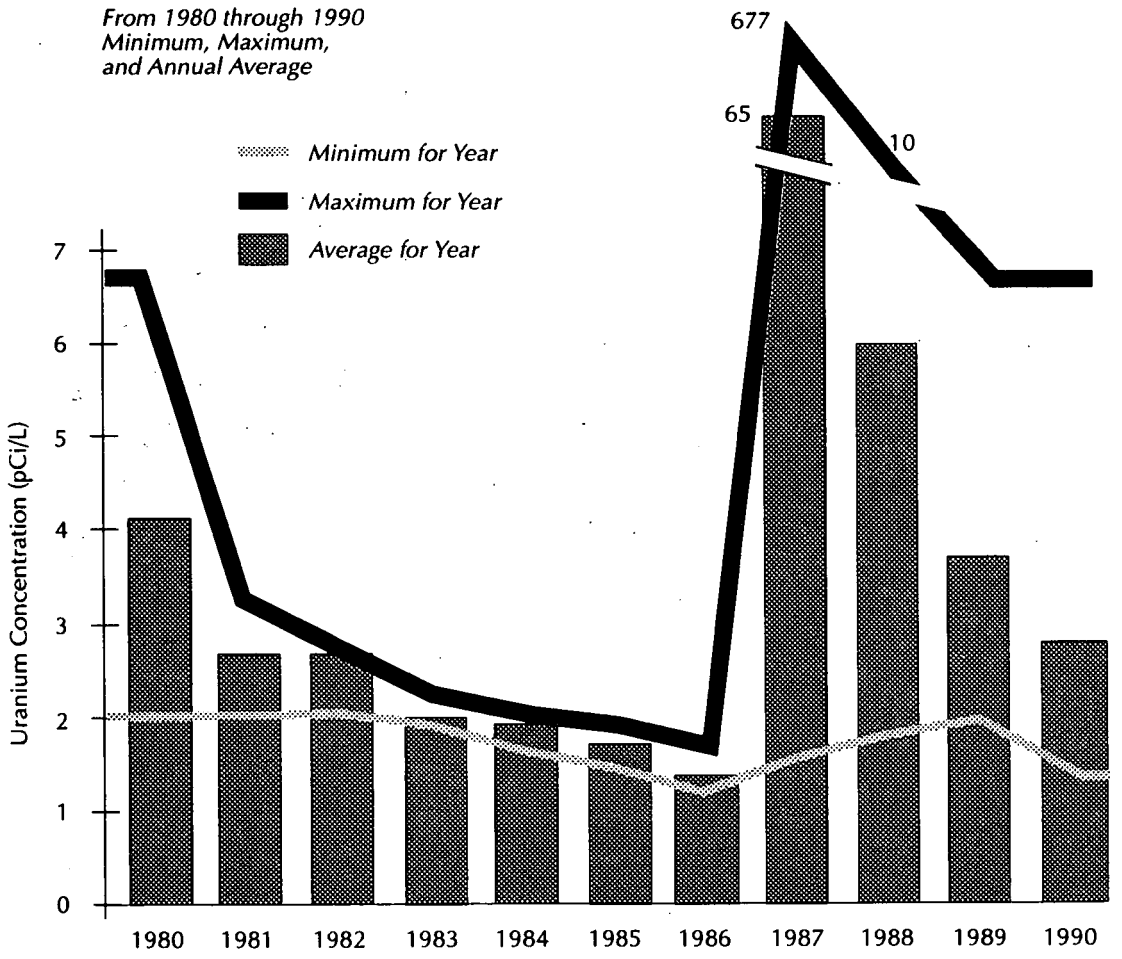


FIGURE 66: Uranium Concentration in Well 3005, 1980 to 1990

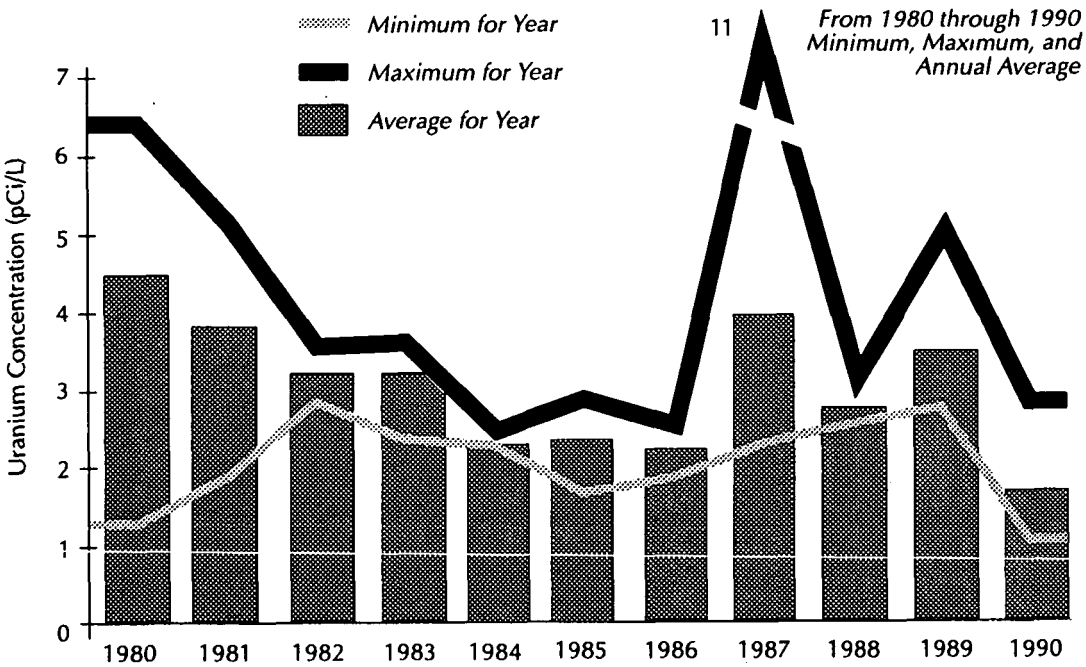


FIGURE 67: Uranium Concentration in Well 3008, 1980 to 1990

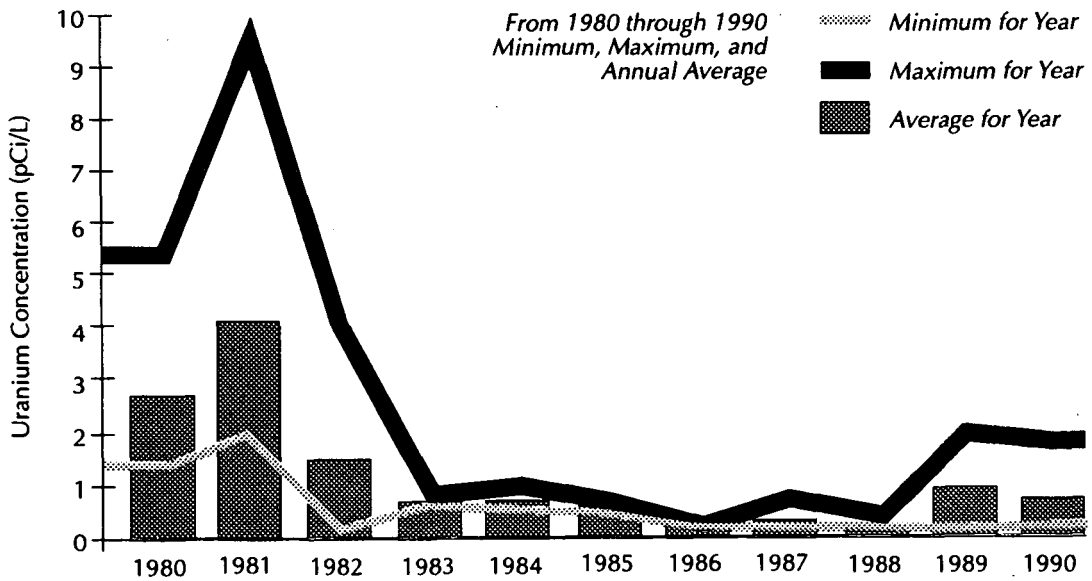


FIGURE 68: Uranium Concentration in Well 3009, 1980 to 1990

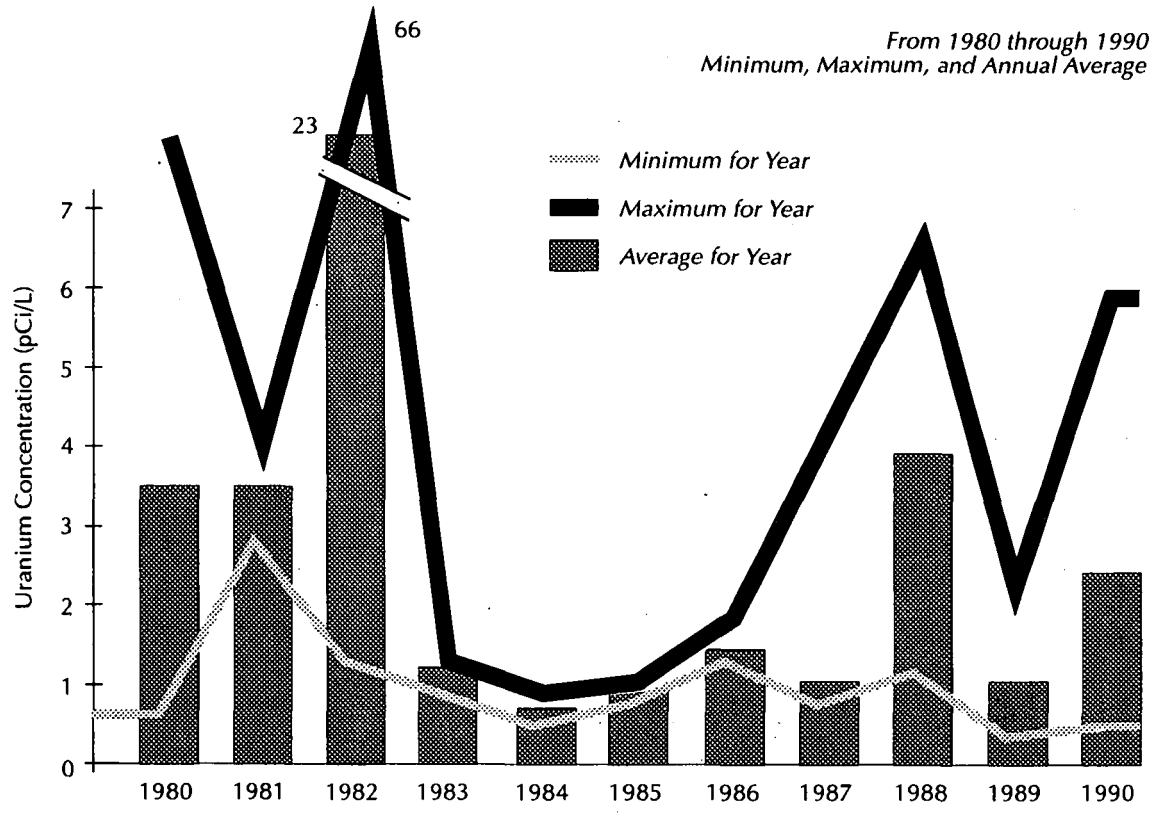


FIGURE 69: Uranium Concentration in Well 3010, 1982 to 1990

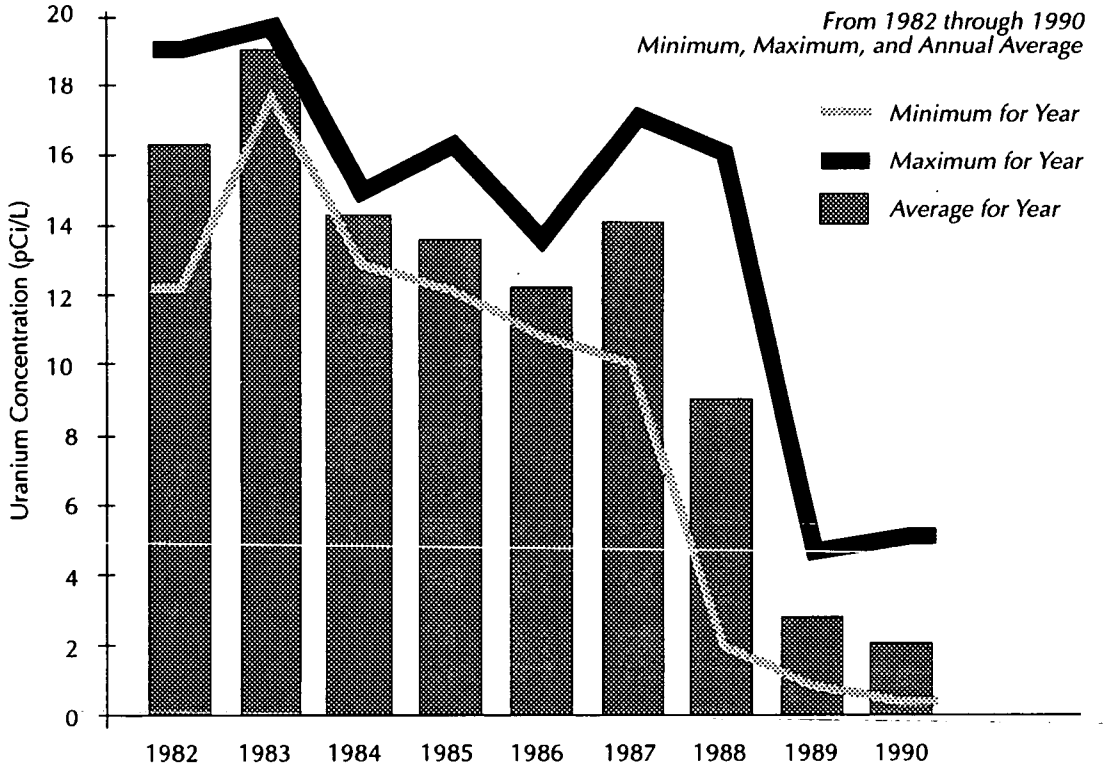


FIGURE 70: Uranium Concentration in Well 4001, 1980 to 1990

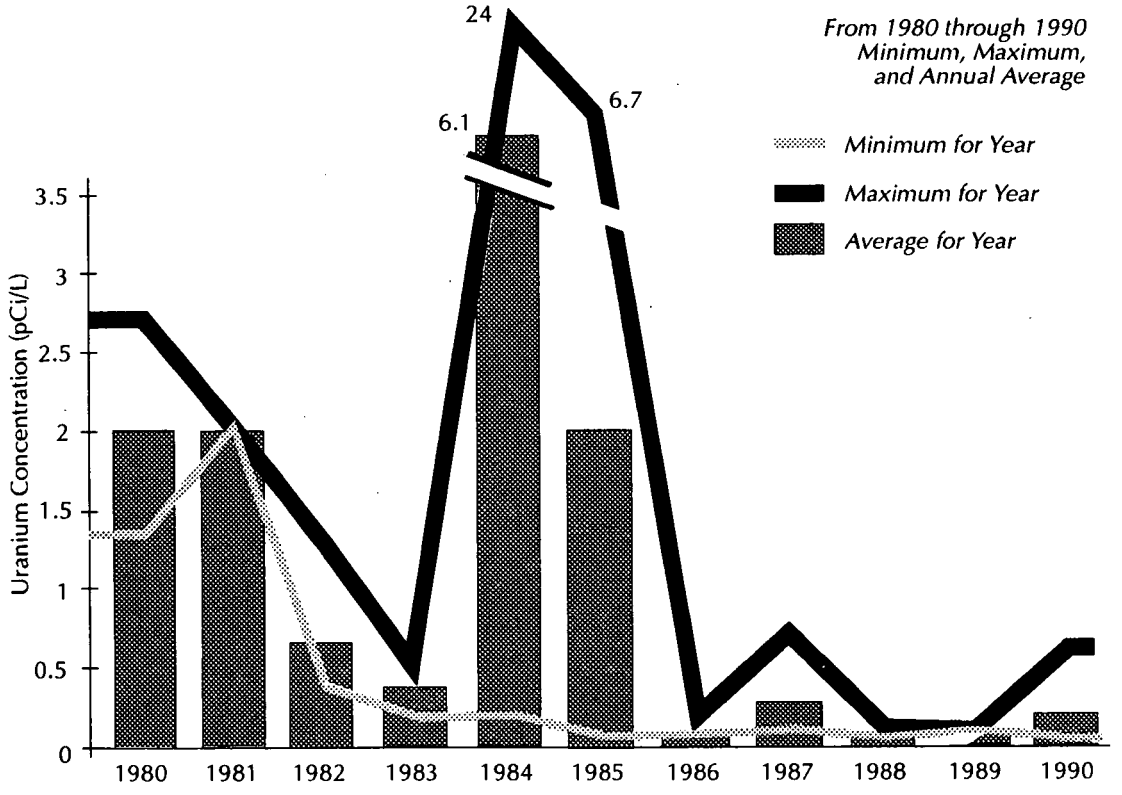


FIGURE 71: Uranium Concentration in Well 4008, 1980 to 1990

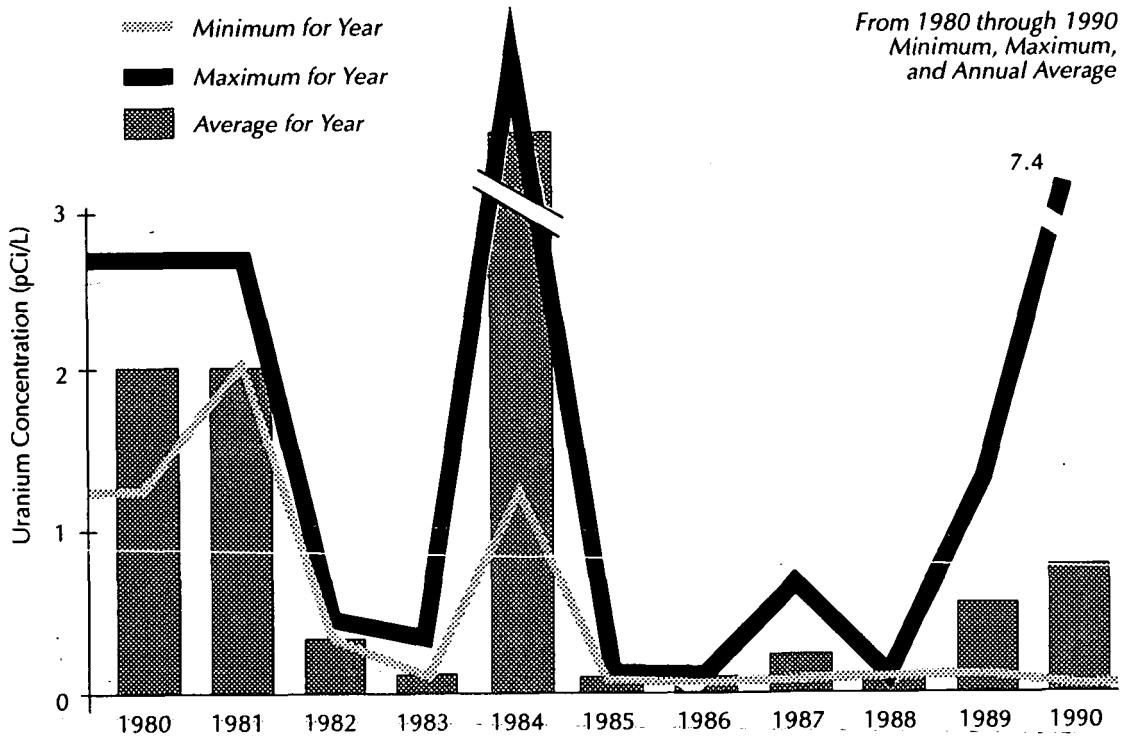


FIGURE 72: Uranium Concentration in Well 4101, 1980 to 1990

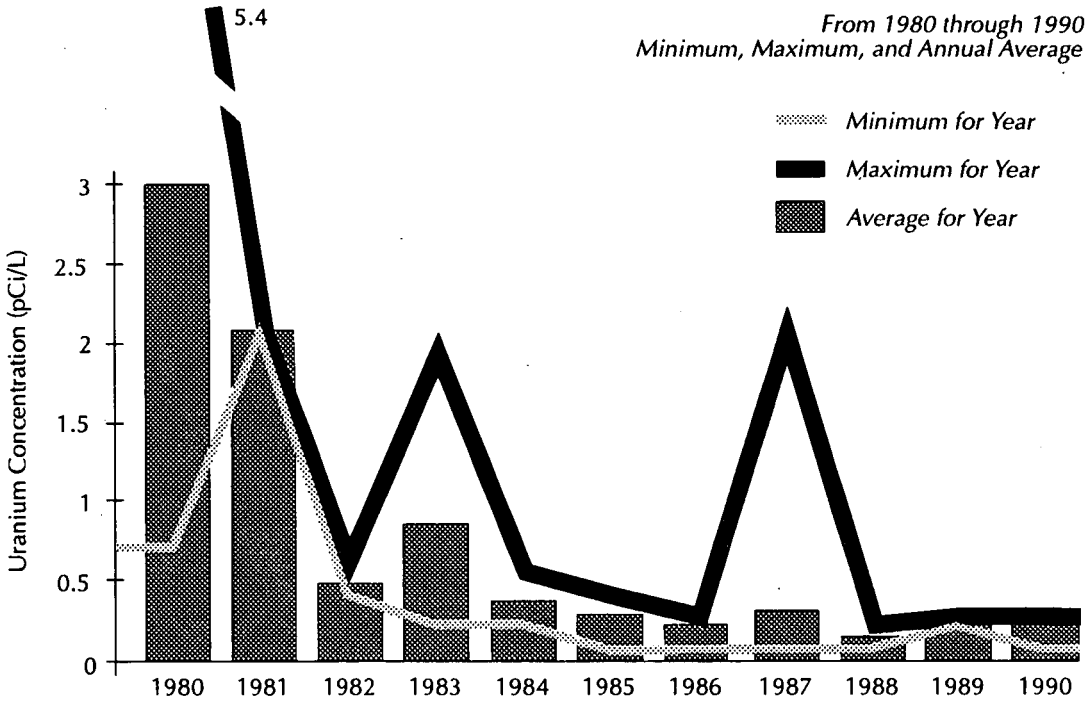


FIGURE 73: Uranium Concentration in Well 4102, 1980 to 1990

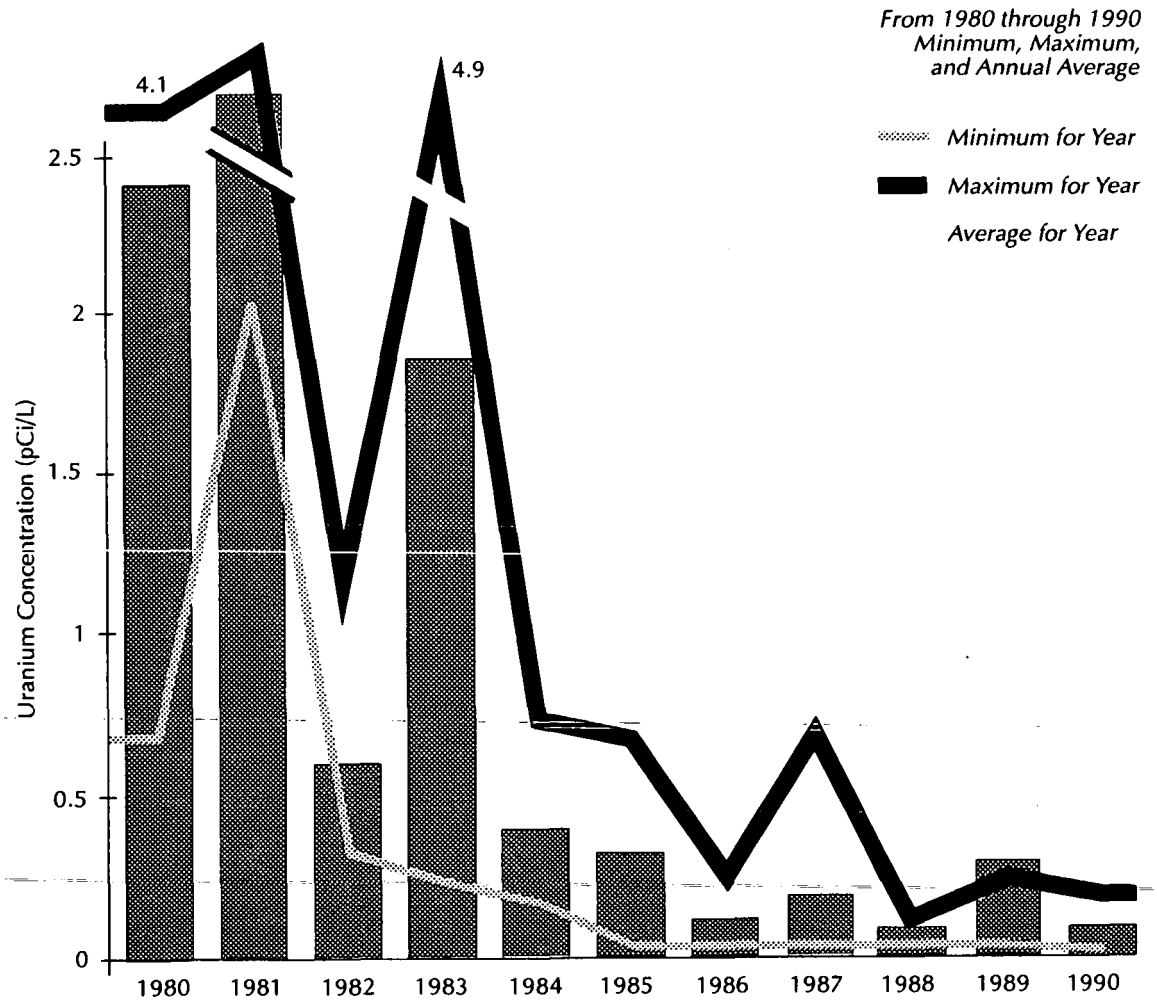
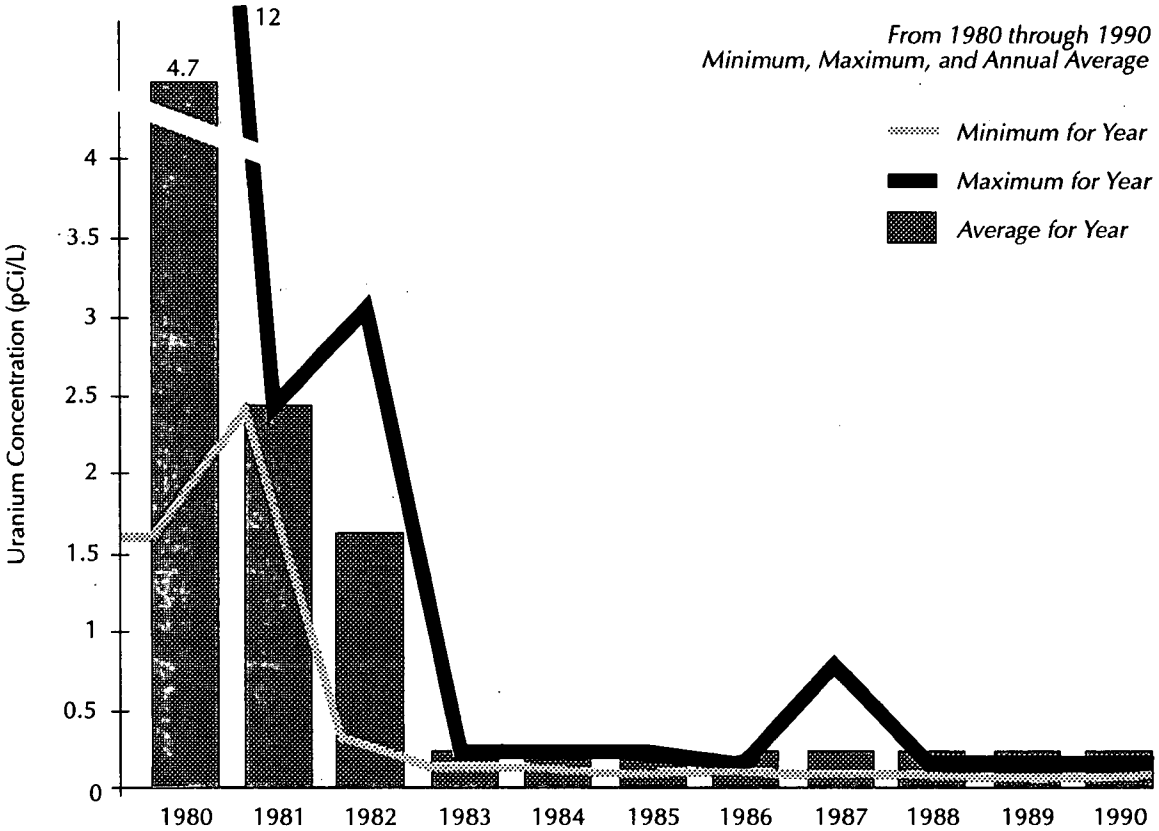


FIGURE 74: Uranium Concentration in Well 4103, 1980 to 1990



APPENDIX C

Chemical Release Information for 1990

Among the information presented in the Annual Environmental Report for the FMPC are estimates on both radiological and nonradiological emissions to the environment. The information in this appendix includes chemical release estimates from the Superfund Amendments and Reauthorization Act of 1986 (SARA) 313 report for 1990 and a summary of emissions from the FMPC Boiler Plant during 1990.

To estimate releases, the FMPC used a method that followed guidelines defined under SARA 313. These estimates do not reflect actual measured emissions. Rather, the FMPC estimated releases via material balance calculation, monitoring data, or engineering calculations. In cases where quantitative monitoring data, inventory estimates, or emission factors were not readily available, release estimates were based on best engineering judgments. Information obtained from air permits, rate of operation, quantities used, and known treatment efficiencies were used to estimate quantities released into the environment. Typically, assumptions based on best engineering judgement were required in order to perform the calculations when all variables were not known.

Calculations for Boiler Plant emissions were based on published AP–42 emission factors and coal use and analysis records for the FMPC during 1990.

The SARA 313 chemicals included in this addendum are a summary of the SARA Title III, Section 313 report, required by SARA legislation. This report is submitted to the USEPA and OEPA each year on July 1 for the previous calendar year and contains chemicals on the USEPA's toxic substance list. Any listed chemical manufactured in excess of 25,000 pounds, processed in excess of 25,000 pounds, or otherwise used in excess of 10,000 pounds at a facility during 1990 must be reported.

FMPC Chemical Release Information for 1990

Section One: Summary of SARA 313 Report

Chemical Name	Type of Release	Quantity Released (lb/kg)	Major Release Sources	Basis of Estimate
Hydrochloric Acid	Air: fugitive	24/11	Ancillary Uses [a]	Best Engineering Judgement
	Air: point source	45/20	Coincidental Manufacturing	Published Emission Factors
Methanol	Air: fugitive	190/86	Chemical Processing Aid	Published Emission Factors
	Air: point source	260/120	Chemical Processing Aid	Published Emission Factors
	Water: Great Miami River	2,400/1,091	Chemical Processing Aid	Best Engineering Judgement
Nitric Acid	Air: fugitive	86/39	Chemical Processing	Published Emission Factors
Sulfuric Acid	None	N/A	Ancillary Use [b]	Best Engineering Judgement

Section Two: Boiler Plant Emissions

Chemical Name	Type of Release	Quantity Released (lb/kg)	Major Release Sources	Basis of Estimate
Particulates	Air: stack emissions	34,000/15,400	Fossil Fuels Combustion	Stack Testing
Sulfur Dioxide	Air: stack emissions	677,000/307,000	Fossil Fuels Combustion	AP–42 Emission Factors [c]
Nitrogen Oxide	Air: stack emissions	326,000/148,000	Fossil Fuels Combustion	AP–42 Emission Factors
Carbon Monoxide	Air: stack emissions	116,600/52,900	Fossil Fuels Combustion	AP–42 Emission Factors
Non-methane Volatile Organic Compounds	Air: stack emissions	1,631/740	Fossil Fuels Combustion	AP–42 Emission Factors

(a) Chemical processing aid to decontaminate equipment and materials. The waste HCL is pH neutralized and released to the general sump.

(b) Chemical processing aid during pH adjustment and regeneration of ion exchangers.

(c) Calculations were based on AP–42 emission factors and 1990 FMPC coal use and analysis records.

APPENDIX D

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APPENDIX E

Glossary of Terms

Activity the rate of disintegration, expressed as disintegrations per second (becquerels) or in units of curies (one curie = 3.7×10^{10} becquerels).

Alpha particle type of particulate radiation (identical to the nucleus of the helium atom) consisting of two protons and two neutrons.

Aquifer a body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs.

ALARA a phrase and acronym (as low as reasonably achievable) used to describe an approach to radiation exposure and emissions control or management whereby the exposures and resulting doses to the public are maintained as far below the specified limits as economic, technical, and practical considerations will permit.

Aliquot the fraction of a field sample taken for complete processing through an analytical procedure (a "laboratory sample" of a field sample).

Beta particle type of particulate radiation emitted from the nucleus of an atom that has a mass and charge equal in magnitude to that of the electron.

Blank a sample of the carrying agent (gas, liquid, or solid) normally used to selectively measure a material of interest that is subjected to the usual analytical procedures process to establish a baseline or background value. This value is then used to adjust or correct the routine analytical results.

Calibration the adjustment of the system and the determination of system accuracy using known sources and instrument measurements. Adjustment of flow, temperature, humidity, or pressure gauges and the determination of system accuracy should be conducted using standard operating procedures and sources that are traceable to the National Institute of Standards and Technology.

Confidence Coefficient the chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%. For a given sample size, the width of the confidence interval increases as the confidence coefficient increases.

Confidence Interval a value interval that has a designated probability (the confidence coefficient) of including some defined parameter of the population.

Contamination any substance or material that is somewhere it is not supposed to be.

Critical Organ the human organ or tissue receiving the largest fraction of a specified dose limit.

Critical Pathway the specific route of transfer of radionuclides from one environmental component to another that results in the greatest fraction of an applicable dose limit to a population group or an individual's whole body, organ, or tissue.

Curie (Ci) and Becquerel (Bq) are units of radioactivity that measure the rate of spontaneous, energy-emitting transformations in the nuclei of atoms. One curie equals 37 billion transformations per second. One becquerel equals one transformation per second. One curie (37 billion Bq) of natural uranium is equivalent to a mass of about 1,500 kilograms (3,300 lb).

Daughter a nucleus that results from radioactive decay. Also, progeny.

Decay the disintegration process of an atomic nucleus.

Derived Concentration Guide the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (for example, drinking water or breathing the air) that would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and the lens of the eye.

Dose quantity of radiation absorbed in tissue.

Effluent Monitoring the collection and analysis of samples or measurements of liquid, gaseous, or airborne effluents for the purpose of characterizing and quantifying contaminants and process stream characteristics, assessing radiation exposures to members of the public, and demonstrating compliance with applicable standards.

Enrichment a process to increase the percentage of a desired isotope such as uranium - 235.

Environmental Detection Limit the lowest concentration at which a radionuclide in an environmental medium can be unambiguously distinguished for a given confidence level using a particular combination of sampling and measurement procedures, sample volume, analytical detection limit, and processing procedure.

Fugitive Dust dust that did not flow through a production stack. This includes materials such as dust from the waste storage areas, administration areas, and dust that originated from construction activities.

Gamma Ray type of electromagnetic radiation of discreet energy emitted during radioactive decay of many radioactive elements.

Half Life the length of time for half the atoms of a given radioactive substance to decay.

ICRP International Commission on Radiological Protection is an organization founded in 1928 and whose function is to recommend international standards for radiation protection.

Ionization removal of electrons from an atom, such as by means of interaction with radiation.

Isotope atoms with the same atomic number but different mass number. Isotopes usually have the same chemical properties, but could have very different radiological properties (such as half-life and type of radiation emitted).

Less than Detectable refers to a measurement or calculated concentration that is not statistically different from the associated background or control value at a selected confidence level.

Lower Limit of Detection the smallest amount of a contaminant that can be distinguished in a sample by a given measurement procedure at a given confidence level.

Minimum Detection Level the minimum amount of the constituent or species of interest that can be observed by an analytical instrument and distinguished from background and instrument noise with a specified degree of probability.

Mixed Wastes hazardous waste that has been contaminated with low-level radioactive materials.

Monitor 1) to measure certain constituents or parameters in an effluent stream continuously or at a frequency that permits a representative estimate of the amount over a specified interval of time;
2) the instrument or device used in monitoring.

NCRP National Council on Radiation Protection and Measurements chartered by U.S. Congress in 1914 and charged with developing radiation protection standards.

Nuclide a general term applicable to all atomic forms of the elements, including isotopes.

Occurrence any sudden release or sustained deviation from a regulated or planned performance of an operation that has environmental protection and compliance significance.

Onsite refers to the area within the boundaries of a facility or site that is or can be controlled with respect to access by the general public.

Operable Unit a discrete action that comprises an incremental step toward comprehensively addressing site problems. Operable units may address geographical portions of a site, specific site problems, or initial phases of

an action performed over time, or any actions that are concurrent but located in different parts of the site.

Person-rem collective dose to a population group. For example, a dose of one rem to ten people results in a collective dose of ten person-rem.

Plate Out a thermal, electrical, chemical, or mechanical action that results in a loss of material by deposition on surfaces.

Point Source the single defined point (origin) of a release such as a stack, vent, or pipe.

Radioactive Material refers to any material or combination of materials that spontaneously emits ionizing radiation.

Radioisotope a radioactive isotope.

Radionuclide refers to a radioactive nuclide. There are several hundred known radionuclides, both artificially produced and naturally occurring; radionuclides are characterized by the number of neutrons and protons in an atom's nucleus and their characteristic decay processes.

Radioactive Emissions releases of radioactive materials to the environment.

Random Samples samples that are obtained in such a manner that all items or members of the lot, or population, have an equal chance of being selected in the sample.

Remedial Action an action that is consistent with the final remedy following a formal examination of the nature and extent of the release, or threat of release, assessment of the risk, and selections of the final remedy based on an evaluation of possible alternatives (RI/FS process).

Removal Action any necessary action to abate an immediate threat to health and the environment, including actions necessary to monitor, assess, or evaluate the threat.

Representative Sample a sample taken to depict the characteristics of a lot or population as accurately and precisely as possible. A representative sample may be a "random sample" or a "stratified sample" depending upon the objective of the sampling and the characteristics of the conceptual population.

Roentgen (R) and Coulombs per Kilogram (C/kg)
units of exposure to radioactivity. One R equals 2.6×10^{-4} C/kg, and is a measure of the ionization in air due to a source of radioactivity.

Roentgen Equivalent Man (rem) and Sievert (Sv)
units of dose which account for the relative biological damage due to the type of radiation involved. One rem equals 0.01 Sv.

Sample 1) a subset or group of objects selected from a larger set, called the population;
2) an extracted portion of a subset of an effluent stream or environmental medium.

Sampling the extraction of a prescribed portion of an effluent stream or of an environmental medium for purposes of inspection and/or analysis.

Sensitivity the minimum amount of a radionuclide or other material of interest that can repeatedly be detected by an instrument, system, or procedure.

Site Characterization designed to provide the information needed to identify site hazards and to select worker protection methods.

Spiked Sample a normal sample of material (gas, liquid, or solid) to which a known amount of some substance of interest is added. Spiked samples are used to check on the performance of a routine analysis or the recovery efficiency of an analytical method.

Tolerance Limits a particular type of confidence limit used frequently in quality control work, where the limits apply to a percentage of the individual values of the population.

APPENDIX F

Annual Environmental Report Distribution List

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